MONTHLY WEATHER REVIEW.

Editor: Prof. CLEVELAND ABBE. Assistant Editor: HERBERT C. HUNTER.

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The MONTHLY WEATHER REVIEW is based on data from about 3500 land stations and many ocean reports from vessels taking the international simultaneous observation at Greenwich noon.

Special acknowledgment is made of the data furnished by the kindness of cooperative observers, and by R. F. Stupart, Esq., Director of the Meteorological Service of the Dominion of Canada; Señor Manuel E. Pastrana, Director of the Central Meteorological and Magnetic Observatory of Mexico; Camilo A. Gonzales, Director-General of Mexican Telegraphs; Capt. I. S. Kimball, General Superintendent of the United States Life-Saving Service; Commandant Francisco S. Chaves, Director of the Meteorological Service of the Azores, Ponta Delgada, St. Michaels, Azores; W. N. Shaw, Esq., Director Meteorological Office, London; Maxwell Hall, Esq., Government Meteorologist, Kingston, Jamaica; Rev. L. Gangoiti, Director of the Meteorological Observatory of Belen College, Havana, Cuba.

As far as practicable the time of the seventy-fifth meridian is used in the text of the MONTHLY WEATHER REVIEW.

Barometric pressures, both at land stations and on ocean vessels, whether station pressures or sea-level pressures, are reduced, or assumed to be reduced, to standard gravity, as well as corrected for all instrumental peculiarities, so that they express pressure in the standard international system of measures, namely, by the height of an equivalent column of mercury at 32° Fahrenheit, under the standard force, i. e., apparent gravity at sea level and latitude 45°.

FORECASTS AND WARNINGS.

By Prof. E. B. GARRIOTT, in charge of Forecast Division.

IN GENERAL.

The general weather features of October, 1907, conformed rather closely to seasonal averages. Barometric pressure over middle and northern latitudes of the continents increased, and a corresponding decrease occurred in the high latitudes of the oceans. The second decade of the month was marked by storms of exceptional violence over the eastern Atlantic and western Europe. This stormy period culminated on the 18th, when barometric pressure reached a reported minimum of 28.60 inches at Valentia, Ireland. During the prevalence of the storms over the Atlantic and Europe high barometric pressure and fine weather prevailed over the United States east of the Rocky Mountains. After the 20th the movement of barometric areas over the Northern Hemisphere was rapid. On the Atlantic coast the severest storm of the third decade prevailed from the 28th to 30th. No well-defined storm advanced northward from the West Indies. The lower Lakes were visited by storms of notable strength on the 7th and 27th. Ample and timely warnings were issued in connection with all storms that visited the seacoasts and Great Lakes of the United States.

The most important local storm reported for the month moved northeastward over Galveston, Tex., at 12:30 a. m. of the 30th, with a wind velocity, at the Weather Bureau station, of 64 miles an hour for a five-minute period and an extreme velocity for two minutes of 76 miles an hour. The barometer fell and rose .30 of an inch in fifteen minutes. Many buildings were wrecked, and one person was reported killed and many injured.

Snow was reported in the mountains of New York and New England on the 20th, in upper Michigan on the 27th, and in the mountains of Virginia and West Virginia on the 28th.

On the 1st, light to heavy frosts occurred in the Lake region, and light frost in the Ohio Valley. On the morning of the 2d frost was heavy in the interior of New York and New England and light as far south as Virginia. Heavy frost was reported in Kansas, Nebraska, Wisconsin, and Michigan on the 8th, and light frost in the Texas panhandle. On the 9th, heavy frost occurred in the Ohio Valley, the lower Lakes, and the interior of the Middle Atlantic States. The first general frost-bearing cool wave of the season moved from the middle Missouri and upper Mississippi valleys to the Atlantic coast from the 12th to 15th, with heavy to killing frosts as far south as the interior portions of the middle and east Gulf and South Atlantic States. Heavy frost occurred in the interior of the Southeastern States on the 22d and 29th, and on the latter date light frost was reported in the interior of northern Florida.

BOSTON FORECAST DISTRICT.*

[New England.]

Monthly means did not depart greatly from October averages. Gales on the 7–8th caused considerable damage to shipping, and a severe storm prevailed on the 28-29th. There were slight snowfalls in Maine, New Hampshire, and Vermont on the 20th.—*J. W. Smith, District Forecaster.*

NEW ORLEANS FORECAST DISTRICT.*

[Louisiana, Texas, Oklahoma, and Arkansas.]

October was warmer than usual with rainfall one to two inches above the normal. Frost warnings were issued for northern portions of the district on several dates, and, as a rule, were partially verified. No storm warnings were issued and no general storm occurred on the Gulf coast.—*I. M. Cline, District Forecaster.*

LOUISVILLE FORECAST DISTRICT.*

[Kentucky and Tennessee.]

An almost unbroken spell of dry, pleasant weather prevailed from the 8th to 25th. The rainfall of the month was confined practically to the 3d-4th, 7-8th, and 26-27th. Normal temperature prevailed in the main, altho there were several cool waves. Light frost was general on the 9th, light to heavy frost on the 12th and 13th, and heavy frost on the 14th, 15th, 28th, and 29th. There was also light frost in northern Kentucky on the 19th, 21st, and 22d, and in southeastern Tennessee on the 16th. Frost warnings were issued on the 8th, 12th, 13th, and 28th.—*F. J. Walz, District Forecaster.*

CHICAGO FORECAST DISTRICT.*

[Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas, and Montana.]

No unusual weather conditions prevailed during the month. No severe storms past over the upper Lakes. Storm warnings were issued on five dates in advance of disturbances of moderate intensity. No wrecks were reported on the upper Lakes. No cold wave warnings were issued.—*H. J. Cox, Professor and District Forecaster.*

DENVER FORECAST DISTRICT.*

[Wyoming, Colorado, Utah, New Mexico, and Arizona.]

Temperature was considerably above normal except in the southern portions of New Mexico and Arizona where there was a slight deficiency. Precipitation was in excess in the southern and deficient in the northern portions of the district. Frosts were frequent, but less severe than usual, and their occurrence was generally well covered by the warnings.—*P. McDonough, Local Forecaster, temporarily in charge.*

SAN FRANCISCO FORECAST DISTRICT.†

[California and Nevada.]

From the 15th to 28th showers were frequent over the greater portion of the district, with thunderstorms and heavy hail in the mountains. Rainfall was unusually heavy from San Francisco Bay southward, but was below normal in the northern portion of California. No frost or storm warnings were issued.—*G. H. Willson, Local Forecaster, temporarily in charge.*

PORTLAND, OREG., FORECAST DISTRICT.†

[Oregon, Washington, and Idaho.]

Except for short periods about the middle of the month and near the close of the second decade clear weather prevailed from the 2d to 25th. The last few days of the month were stormy. Frost was frequent east of the Cascade Mountains.—*L. Lodholz, Local Forecaster.*

RIVERS AND FLOODS.

River matters continued without special feature thruout the month. The heavy rains of the 3d and 4th in Texas caused rather rapid rises in the Trinity, Brazos, and Colorado rivers, necessitating advisory warnings; but flood stages were neither anticipated nor reached, and no damage was done. There was also a sharp rise of several feet in the Guadalupe River of Texas during the last two days of the month, advices regarding which were distributed on the 30th. There were heavy rains over the valley of the Connecticut River on the 28th and 29th, and by the morning of the 29th the river was rising rapidly. Warnings for flood stages from Hartford to Long Island Sound were issued on the 30th, and on the morning of the 31st the stage of the river at Hartford was 17.3 feet, 1.3 feet above the flood stage. Considerable inconvenience resulted, but no great damage was done.

The highest and lowest water, mean stage, and monthly range at 202 river stations are given in Table VI. Hydrographs for typical points on seven principal rivers are shown on Chart I. The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.—*H. C. Frankenfield, Professor of Meteorology.*

* Morning forecasts made at district center; night forecasts made at Washington, D. C.

† Morning and night forecasts made at district center.

SPECIAL ARTICLES, NOTES, AND EXTRACTS.

HIGHEST KITE FLIGHT AT MOUNT WEATHER, VA.

[By permission of the Chief of Bureau and thru the kindness of Prof. W. J. Humphreys and Dr. W. R. Blair, we are enabled to print this report on the kite flight on October 3, 1907, the "international date", when the altitude above sea level reached by the leading kite and the meteorograph is believed to be the greatest yet attained in any kite ascension. The flight began at 7:00 a. m., and ended at 11:04 p. m.]

Kite flight of October 3, 1907 (international date).

Time.	Surface conditions (at Mount Weather, 1,725 feet above sea level).				Conditions aloft.			Clouds.
	Temp.	Rel. hum.	Direction of wind.	Velocity of wind.	Elevation above sea level.	Temp.	Direction of wind.	
	°F.	Per ct.		m. p. h.	Feet.	°F.		
7:00 a. m.	62.7	78	w.	17	1,725	62.7	w.	
7:21 a. m.	64.2	75	w.	16	2,524	67.5	wnw.	4 ci. w.
8:30 a. m.	68.0	66	w.	14	2,980	71.8	nw. by w.	
10:16 a. m.	71.0	62	w.	13	4,906	62.4	w.	1 ci.-s. w. 1 a.-cu. nw.
12:30 p. m.	72.5	65	w.	10	7,472	49.8	wsw.	1 cu. w. 1 a.-cu. nw. 9 s.-cu. wnw.
1:27 p. m.	73.4	64	w.	8	10,376	39.7	w. by n.	6 a.-cu. nw. few cu. nw.
2:53 p. m.	74.5	62	s.	9	14,606	33.1	nw. by w.	2 a.-s. wnw. 5 s.-cu w.
3:44 p. m.	73.5	62	s.	7	16,738	24.1	wnw.	3 a.-s. wnw. 2 s.-cu. w.
4:40 p. m.	72.7	62	s.	8	19,198	14.7	wnw.	
5:33 p. m.	71.4	63	sw.	9	21,973	+ 1.8	wnw.	
6:05 p. m.	70.0	65	s.	10	23,110	− 5.4	wnw.	2 a.-s., wnw.
7:57 p. m.	70.4	62	sw.	11	21,116	+ 6.1	wnw.	
8:40 p. m.	70.9	61	sw.	12	18,710	13.3	wnw.	clear sky.
9:18 p. m.	71.0	60	sw.	13	12,667	30.6	w.	
10:12 p. m.	70.0	59	sw.	13	7,491	50.5	wsw.	
10:34 p. m.	70.0	58	sw.	12	5,733	57.2	wsw.	
10:50 p. m.	70.5	58	sw.	13	3,836	63.7	wsw.	
11:04 p. m.	70.3	55	sw.	14	1,725	70.3	sw.	

Notes.—Cumulus cloud elevation at 1:53 p. m. about 6,500 feet, one cloud passing under fourth kite.

Pressure at maximum altitude, 12.56 inches.

The flight was made with eight kites, having a combined lifting surface of 505 square feet. Four kites, 2,500 feet apart, were placed at the upper end of the line, and, beginning at 18,500 feet, four more, about 5,000 feet apart, were added.

Wire out at maximum elevation was 37,300 feet; maximum wire out was 38,500 feet. The length and size of the piano wire used for the line was as follows:

Diameter.	Length.
Inch.	*Feet.*
.026	2,500
.028	5,000
.032	11,000
.036	20,200

The barometer was high over the Carolinas and low over the upper Mississippi Valley.—*W. R. B.*

INTERCONVERSION OF CENTIGRADE AND FAHRENHEIT SCALES.

By F. K. FERGUSON, Superintendent of Schools. Dated Paola, Kansas, November 23, 1907.

I notice in the February, 1907, number of the MONTHLY WEATHER REVIEW, an article on pages 62 and 63 entitled "Interconversion of centigrade and Fahrenheit degrees." I was much interested in the article, as I have invented a method of interconversion of these scales which, laying aside the question as to whether it is easy to "divide by 5 and multiply by 9," is a very easy rule to remember. The difficulty is not so much the dividing by 5 and the multiplying by 9 as it is to remember, on the spur of the moment, whether we add 32 and then take $\frac{9}{5}$ or take $\frac{9}{5}$ and then add 32; or whether we subtract 32 and then take $\frac{5}{9}$ or take $\frac{5}{9}$ and then subtract 32.

The following are my rules: To convert Fahrenheit reading to centigrade reading—to the Fahrenheit reading add 40, take $\frac{5}{9}$ of the sum, and then subtract 40. To convert centigrade reading to Fahrenheit reading—to the centigrade reading add 40, take $\frac{9}{5}$ of the sum, and then subtract 40. Or by formulas:

$$C. = \tfrac{5}{9}\,(F. + 40) - 40.$$
$$F. = \tfrac{9}{5}\,(C. + 40) - 40.$$

You see this method is simple and easy to remember, for in each case the process is exactly the same, excepting the fractions $\frac{5}{9}$ and $\frac{9}{5}$. But it is quite easy to remember which fraction to use in the given case; for if it is Fahrenheit reading that you have, the centigrade for which you are figuring is to be a smaller reading; hence use the smaller fraction, $\frac{5}{9}$. Likewise when you have centigrade and are figuring for Fahrenheit, use the fraction $\frac{9}{5}$.

STUDIES OF FROST AND ICE CRYSTALS.

By WILSON A. BENTLEY. Dated Jericho, Vt., May 28, 1906. Revised July, 1907.

(Continued from September Review.)

(36) Type WLF. Solid lamellar crystals.

Crystals of this type, like the preceding, form upon tiny ice or frost particles on the window glass, and grow detached from the glass, except where their nuclei are in contact with it. They develop in the form of thin hexagonal laminæ, or plates, growing in practically the same manner and under the same general conditions, except at somewhat colder temperatures, that prevail during the formation of crystals of type WSE; and are like them a type of indoor hoarfrost. They grow in a slow and intermittent, rather than in a continuous manner, and preserve the plain hexagonal form intact, except possibly at brief intervals, when new additions begin to grow outward from each of the six corners of the lamellar hexagons.

Perhaps the most interesting features about them are the systems of lines and shadings that thread their interiors, due to included air. These have a similar aspect and arrangement to those that occur within many solid tabular snow crystals. In some cases they even possess delicate circular lines encircling nuclear portions corresponding to those which occur within certain types of snow crystals, and which Mr. A. W. Waters called "meandering lines". They differ, however, in most cases from solid tabular snow crystals in this, that the air tubes and shadings within them, going to form their interior structure, lack the perfect symmetry of arrangement of the similar features that occur within the snow crystals.

Yet in some cases almost perfectly symmetrical solid tabular hexagonal structures are built up around such imperfect nuclei or nuclear portions. No. 171 is a case in point, and it will be noted how closely this one and No. 180 A resemble some of the solid snow crystals.

The series of photographs, Nos. 32, 53, 58, 59, 117, 129, 171, and 180 A, portrays typical and fine examples of this type of window-frost crystals. Photograph No. 180 B shows a beautiful group of such crystals. Among the more interesting specimens of this series is No. 180 A. It shows two crystals, one of them a very interesting "twin" crystal. No. 129 shows two solid tabular crystals lying so close one to another that it is very likely that could they but have grown a little longer they also would have united and formed a twin crystal similar to the one in No. 180 A. It is interesting to note that the outlying portions and segments of each of these crystals grew much faster and to a greater size than did the segments of each that lay closest to the neighboring crystal. The photograph No. 117, showing tiny, solid hexagonal crystals clustered around a window-frost crystal of type WFC, is of very great interest as showing how in some cases changes in temperature and humidity cause certain types of crystals to cease to grow, and cause crystals of another and opposite type to form and grow around them. In this case the tiny, outlying, solid, hexagonal crystals formed in a much colder, and presumably somewhat drier atmosphere than that in which the curving nuclear crystal was formed.

(37) Type WCG. Columnar forms.

This type of window frost occurs in the form of short, squareended hexagonal columns. They correspond to the solid, hexagonal, columnar forms of snow and hoarfrost crystals, but unlike them they form in such a way, with one of their sides in contact with and attached to the window glass, that they rarely grow in the form of complete hexagonal columns, but in most cases in segmental form only; i. e., so as to resemble solid columns bisected longitudinally. They are very coldweather types and form only in cold rooms, and in a very cold atmosphere. In many cases crystals of this type form when the outdoor temperature ranges from −10° to −30° F., and the indoor from 15° F. downward. They are rarely found distributed evenly over the whole surface of a given windowpane, but usually occur in clustered array upon some one or more local portions only. In many cases they occur associated together upon the same pane of glass with types WSE and WLF. They are usually quite small in size, and evidently belong to the class of crystals that grow slowly, and that form freely only within a very cold and somewhat humid atmosphere. Within the coldest of my rooms they formed most freely at humidities of 83 to 86 per cent, and within the warmer rooms only when the relative humidity exceeded 60 per cent. Photograph No. 156 shows a group of such crystals, while No. 157 shows some of them viewed endwise. The latter are magnified much less than the former.

It is of interest to note that the interior structures of such crystals and the figures outlined therein closely resemble those that occur within the solid tabular snow crystals. The writer's photographs of solid columnar snow crystals, reproduced in the memoir "Studies among the snow crystals, winter of 1901–2",[5] exhibit sets of shadings and figures that resemble those within solid columnar window-frost crystals. The splendid and correct drawings of solid tabular snow crystals made by Mr. A. Dobrowolski, member of the Belgica Antarctic expedition, and published by him in his very interesting and richly illustrated work, entitled "La Neige et le Givre", also show structures and sets of interior figures that resemble those within solid columnar window-frost crystals.

(38) Type WOH. Open-structure forms.

It has proved impossible to find a word that will convey an impression of the forms of this singular type of window frost. It possesses primary and many tiny, slender secondary rays, and the whole is so arranged as to outline open hexagonal and other figures. The secondary rays usually project from the primary ones at angles of 60°. This type of crystal also is common only to cold rooms, and to medium and low temperatures. It is often found associated with types WSE, WLF, and WBB.

Photographs Nos. 86, 120, 121, 127, and 132 will serve to give a much more correct idea of this odd type of crystal than words can convey. This type and also type WFJ seem to be common only to quite humid atmospheres, for they formed not at all within the least humid of my several rooms. They seem to form most freely at relative humidities of 55 to 65 per cent.

(39) Type WTI. Tooth-shaped crystals.

This type of crystal, as its name implies, assumes tooth-like or spike-like forms. It forms only within cold rooms and under practically the same conditions, temperatures, etc., as prevail during the formation of types WLF, WCG, WSE, and WMD, with which it is often found associated. Nos. 32 and 58 B contain specimens of the tooth-like crystals and No. 59 of the long spike or rod-like forms.

(40) Type WFJ. Fibroid crystals.

Window-frost crystals of this type consist of a vast number of slender, curving or straight, icy fibers lying close together or in partial contact one with another and all lying in the same general direction, as shown in photographs Nos. 28 A and 28 B. They form within relatively warm rooms and perhaps most often when a rapid and considerable fall in outdoor temperature is in progress. They seem to be common only to quite humid atmospheres, possessing a relative humidity of from 60 to 90 per cent, and to relatively mild temperatures (from 30° to 15° F. indoors).

This closes our mention of special types of window-frost crystals; yet there are others that are perhaps entitled to be considered distinct types. Those shown in photograph No.

[5] See Monthly Weather Review, Annual Summary, 1902.

166, for instance, are a case in point, but space forbids further mention of particular types, except the one next to be considered.

(41) Type WGK. Granular window frost.

This type of frozen "granular dew-like" frost, if such it may be called, is of a noncrystalline character and is of very common occurrence. It is peculiarly the product of a very humid atmosphere and is most common to warm, artificially heated rooms. It consists, as first formed on windowpanes, of countless myriads of tiny, microscopic, liquid water particles crowded together upon the glass. In mild winter weather they may retain that liquid character for hours together, but during cold weather the tiny dewdrop-like liquid particles are frozen once they touch the glass and converted into tiny, rounded, icy granules thereon. (In rare cases the granules assume a more definite crystalline form.) The individual granules as deposited at the first stage vary in size from perhaps $\frac{1}{100}$ to $\frac{1}{300}$ of an inch in diameter, and lie for the most part near to, but slightly apart from, one another. Commonly the granules retain their original size and form only a short time, because deposits of moisture like themselves form upon and attach themselves to them, augmenting their size until eventually all, or nearly all, merge together and form a thin but continuous film of granular ice. This is its second stage of formation.

(42) Rapidity of formation.

Unlike true frost crystals, which usually form and grow slowly, granular window-dew frost often forms very rapidly; and in many cases, as during zero weather or when for any cause the air in immediate contact with the glass is momemtarily made more humid, it forms in instantaneous order.

(43) Experiments in formation and repulsion of window frost.

During zero weather most interesting experiments may be made by placing a lighted lamp close to a frosted windowpane and allowing it to remain until a large space at the center of the glass is made dry and free from moisture or water film. Around this dry space a film of water should be left upon the glass for window-ice crystals to form in. When the lamp is removed window-ice crystals begin to form around the outer edges of the water film and to shoot inward. They cease to grow where the edge of the space of dry glass is reached. Soon tiny true frost crystals of types WLA and WBB form upon certain lower outlying positions of the central dry glass space. Small patches of granular-dew frost, type WGK, soon form and occupy the dry spaces of glass lying around, but not in the immediate vicinity of, the true frost crystals. The latter seem to repel the tiny dew-like water particles while they are in the liquid state and thus prevent them from approaching close to the true crystals; hence a space of unoccupied dry glass is left immediately around such crystals. True frost crystals soon form a little above the upper limits of the granular-covered glass spaces, and are soon in turn once more succeeded by the formation of granular patches around and above them; and these processes are repeated in alternate order until the whole central dry glass space, except those portions lying immediately around the true frost crystals, is completely covered. Ofttimes, as the phenomenon proceeds, deposits of the granular-dew frost will flash forth in instantaneous order upon the glass and instantly cover relatively large glass spaces.

(44) Photographs of phases of repulsion.

The above described repulsion phenomenon is of such interest as to have induced the writer to secure a large set of photographs showing the various phases and stages of the phenomenon, and the diverse ways in which it manifests itself. The following photographs best show this phenomenon of repulsion: Nos. 48, 100, 103, 106, 107, 108, 122, 125, 128, 144, 148. Nos. 17, 80, and 81 are highly magnified photographs, showing the forms and arrangement of the individual particles or granules of which type WGK is composed. Photographs Nos. 128 and 144 show sections of granular films, but slightly magnified. Nos. 100, 106, and 144 exhibit the potency and intensity of this repulsion phenomenon, and the relatively considerable distances from the crystals at which it manifests itself. It will be noted that in these cases it extended outward upon the glass over a region double or treble that of the diameters of the crystals that exerted it. Excessive humidity particularly overcomes the influence and potency of the repulsion agencies, and under such conditions the dew-like granular-frost particles are from the very first forced, as it were, to approach more closely to the true frost crystals than is the case under less excessive conditions of humidity. When such excessively humid conditions continue for a long time granular dew-frost particles are forced to form and to approach progressively nearer and nearer to, and at last to unite with, true frost crystals. For further mention of this phenomenon, and of its probable cause, see section 29.

V.—WINDOW-ICE CRYSTALS IN GENERAL.

(45) Conditions of formation.

Under this title are grouped the various forms of so-called window frost that develop within a very thin film of liquid water on the windowpanes within dwellings, offices, etc., and that are cases of true ice crystallizations.

Window-ice crystals are of very frequent occurrence and assume exquisitely beautiful and varied forms. Countless windowpanes in northern climes are beautified thereby in wintertime, hence their forms and many varied charms must have been made familiar to nearly every one. They are very noticeable because of their large size and feather-like forms. The only condition essential to the formation of window-ice crystals is that there be a film of liquid water upon a windowpane, and that the outdoor temperature be at some point below the freezing point of water. The size of individual window-ice crystals depends upon and is limited only by the area of glass surface covered by such water film, and the time that a single crystal can develop unimpeded therein, i. e., without meeting other growing ice crystals progressing in opposite directions.

(46) The types and method of formation.

Two types of window-ice crystal occur in nature. The crystals of one of these types grow in the form of feathers and feathery plumes, and because of this the type has been called the "feather form" of window-ice crystal; while the other or opposite type grows in the form of delicate branching twigs or trees, and hence is called the "arborescent" type or form. The crystals of the former type are perhaps of most frequent occurrence, and are much more striking and prominent than are those of the opposite type.

The feather-form crystals possess both primary and secondary rays, while arborescent crystals lack such primary rays, and consist of secondary rays only. In the case of feather-form crystals the primary ray or quill comes slightly first in the order of formation, and hence always extends slightly in advance of the secondary rays; and the latter grow outward in general at angles of 60° from the primary ray; and in general both primary and secondary rays grow outward in straight, or but slightly curving fashion. But in the case of the arborescent crystals each of the many secondary rays of which they are composed grows onward independent of the others, in a sinuous and meandering, rather than straight or gently curving, manner. Their respective and differing manners of growth would seem to suggest the idea that the feather form is the result of a relatively powerful and well-defined crystallic tendency, directed forward regardless of obstacles, in straight or but slightly curving manner, whereas the opposite branching type is the result of a much feebler, or at least more diffused, crystallizing tendency, directed also forward,

but in so feeble a manner, that each separate crystallic ray is deflected and must pick its way around, instead of passing straight over, the many tiny obstacles encountered in its path.

(47) Habits of formation.

Window-ice crystals in general seem not to repeat or duplicate the forms assumed at a given time, or at least do so only after long intervals of time, when perhaps identically the same conditions that produced a given design repeat themselves. They form within thin films of water rather than, as in the case of the window-frost crystals, directly upon the dry glass; and hence are much less influenced by scratches or other features of the glass plate than are the latter.

Other conditions being the same, crystallization within thin films of water, spread evenly upon windowpanes, will occur first upon the colder portions of the glass. Subsequent development and habits of growth are doubtless greatly determined by relative temperatures and by variation in the thickness of the water film. In the case of feather-form crystals, curving habits of growth are doubtless in many cases induced as a result of their endeavors to grow away from neighboring crystals, or to seek out and grow toward the cooler regions on the glass, or to avoid the warmer ones.

(48) Factors determining type.

In the case of window-ice crystals, the factors that determine the type and form are as yet but partially known. Both types of crystals grow side by side upon the glass. Yet it frequently happens that, for some inscrutable reason, one type will suddenly cease to grow, and be succeeded by the opposite type. The line of demarcation between the one and the other type is always sharp and well-defined. Possibly the following may be determining factors:

1. Thickness of the water film.
2. Variation in the thickness of the window glass, and—
3. Consequent variation in the temperature of its different portions.
4. Condition of the water film, whether continuous or broken.

(49) Development of window-ice crystals.

Ice crystals as first formed, or in the first stage of existence, are very thin and transparent. At this stage they are quite difficult objects to photograph. During extreme cold, or under the influence of a rapid and continued fall in temperature, they become progressively thicker and more opaque, and are easily photographed. The moisture that collects upon them, once they are organized, is largely of a subcrystalline, or granular dew-like character, and merely increases their thickness and opacity, without altering their type.

Singularly enough, the feather form, IFA, and the branching form, IAB, of window-ice crystals, do not grow or increase in thickness and opacity in the same ratio; the former grows much the faster. During intense and long continued cold, the feathery crystals often increase in thickness to such a degree as to represent a third stage, when they stand out in relief from the branching designs, resembling beautiful sculptured scroll work wrought in *alto-rilievo.*

In somewhat cold but moist rooms, as within barns and mountain observatories, the development of window-ice crystals often proceeds to yet another or fourth stage, in that it is superseded by a species of hoarfrost crystallization, due to the formation of columnar or solid tabular hoarfrost crystals upon the surface of a thick opaque window-ice film. Such crystals develop, in perpendicular fashion, outward from the glass or normally to the ice film.

VI.—CLASSIFICATION OF WINDOW-ICE CRYSTALS.

(50) Type IFA. Feather-form crystals.

We have secured a large number of photographs of these beautiful crystals and have selected the following numbers from among them for illustrative purposes:

Nos. 49, 50, 51, 52, 62, 63, 66 A, 68 A, 68 B, 72, 74, 75, 78, 79, 82, 83, 88, 89, 91, 92, 93, 101, 113, 133, 134, 135, 136, 138, 139, 140, 142, 150, 151, 152, 164, 182, 183, and 189. Many of these are greatly reduced in size, while many others are magnified a few diameters. Some few sections are highly magnified.

(51) Stages of growth.

Nos. 49 and 62 show the crystals during their first or skeleton stage of formation; Nos. 133, 135, 136, 138, and 139 show the second stage, and the manner in which the spaces between the first or skeleton branches are filled in by subsequent growth; while Nos. 66 A, 68 A, 68 B, 72, 88, 134, 140, and 142 show the third stage of formation, and the thick coat of subcrystalline frost-ice, or granular dew-like window-frost, type WGK, that collected on them as the result of their being subjected for some time to a very and increasingly humid atmosphere, due in part to a rapid and considerable fall in outdoor temperature, and in part to steaming kettles indoors.

(52) Special cases.

Many of the photographs of the feather form of window-ice crystal are of great interest and deserve especial mention. No. 62, for example, is among these. This photograph is not, as might be readily supposed, a railroad map, but a highly magnified section of a window-ice crystal. Yet the invisible, but potent, something that we blindly call crystallic impulse, or tendency, which traveled along those tiny crystallographic main lines, is perhaps just as wonderful in a way, if viewed from an atomic or molecular standpoint, as are the ponderous engines of human construction that thunder along the railroad lines represented upon actual railroad maps. We can but wonder whether those mysterious inter-atomic forces, or agencies, that traveled along those tiny microscopic lines, constructing them as they went along, pulled molecules and atoms along with them to build up those complex structures; or whether they drew such from either side; or indeed, whether they did not in fact push atoms and molecules to one side as they past along.

No. 74 also is a highly magnified section of window-ice crystal, type IFA, but in this case crystallic lines are much broader and possess scalloped or rounded, instead of straight, edges, as tho tiny atmospheric or liquid whorls aided in the building of them.

In No. 189 the secondary branches are seen growing and projecting perpendicularly to the primary quill ray. This arrangement is somewhat unusual. Nos. 79, 88 and 93 are fine and instructive examples of further magnified sections of feather-form crystals.

Nos. 136, 138, 139, and 140 are most strange and rare specimens of beautiful feather-form window-ice crystals. They somewhat resemble in form sections of evergreen vine. They formed during sunny zero weather, on a calm afternoon (January 5, 1905), just preceding the terrible hurricane wind of January 6, 1905. Possibly a brief statement of the general conditions that favored their formation may be of interest. The windowpane whereon they formed had a southern exposure, but an adjoining building to the westward gradually cut off the sunlight during the afternoon, leaving it in shadow. This was done in such a way that the sunlight was shut off from the western edge of the window first, and the eastern edge last, hence the region of shade gradually extended across the window from west to east, and of course this operated to cause the western edge of the windowpane to cool off first. As a result, window-ice crystals formed first within the water film covering the western edge of the windowpane, and slowly progressed from west to east, and in horizontal order, across it. Had the windowpane been of a more equal temperature thruout, and as cold at its eastern as at its western edge, window-ice crystals would have formed as quickly at the eastern edge of the pane as at the

western, and hence have developed outward therefrom, and have met and thus interfered with the complete development of the crystals under consideration. Many long, slender, feathery window-ice crystal plumes doubtless owe their origin to causes similar to those just set forth. Long feathery plumes that form at the bottom of windowpanes and develop upward along the central regions of the glass, are cases in point. In this case they form first upon the colder (lower) portions of the glass, and progress upward toward the warmer portions, but enter these only after the glass has become cooled by exterior cold to a point that favors their development thereon.

The crystals Nos. 136, 138, and 140, previously mentioned, were of large size and magnificent proportions. Our photographs show them reduced to one-third the diameters of the originals and at the second stage. Moisture continued to collect upon them during the afternoon of January 5, 1905, owing to a progressive fall in outdoor temperature, and as a result they assumed and past into the third or opaque window-frost stage. For some strange and inexplicable reason, certain local spots, situated at regular intervals along the greater radii, failed to attract as much moisture as others, or operated to repel moisture; hence such spots retained much of their original transparency, and this caused the formation of the wonderful and beautiful white and dark spots that appear, strung bead-fashion, along their radii. Our photograph No. 140 shows the general aspect of the crystals at this third or beaded stage; it shows them much reduced in size, and of course shows but little of the wonderful beauty of the originals. No. 142 is a short magnified section while at the second or beaded stage. There is some mystery why crystals of this type and form do not broaden out and meet one another, instead of growing in such a narrow, banded fashion.

(53) Other special cases of feather-form crystals.

No. 150 of our series shows exquisite scroll-like designs of window-ice crystals. No. 183 portrays a group of exceeding richness and complexity; some of the crystals resemble the evergreen-vine type shown in Nos. 136 and 140. No. 182 pictures a magnificent group of feathers, growing upward from the bottom of a windowpane.

No. 164 includes examples of both "feather" and "branching" forms of window-ice crystals. The latter type may be seen branching outward from the ends of the former. The abrupt manner in which one ceases development and in which the opposite type begins to grow outward, as also the well-defined line of demarcation between them, is well shown in this photograph and also in No. 101.

(54) Type IAB. Arborescent crystals.

The individual crystals of this type are much less beautiful and diversified in form than are those of type IFA. This explains the relative paucity of our photographs of this type. Nos. 84, 87, 92, 94, 149, 153, 164, 165 are typical examples.

No. 87 of this series is a most interesting photograph, showing the manner in which these tiny, slender, crystalline branches wander or meander in a general parallel direction on the glass. No. 165 is of nearly as great interest.

This completes our list of window-ice crystals. Those herein reproduced give but a glimpse into the beauties of the window-ice crystals, and show but a few of their many varied forms. They must be seen in the originals to be seen at their best. Photographs utterly fail to do them justice. It is a delight to know that our windowpanes will for all time be glorified and beautified in winter by these exquisite creations of window ice, and by those other elegant crystal structures that are next of kin to them, the window-frost crystals.

VII.—FORMATION OF ICE AND ICE CRYSTALS.

(55) Observation of crystallization.

The crystallization and solidification of water in mass, as on ponds, brooks, rivers, etc., by freezing in winter, is indeed a most marvelous and instructive phenomenon, and results in the formation of many beautiful and interesting groups of crystals. Yet so minute and very thin and transparent are most ice crystals at their nuclear stage, and so quietly and unobtrusively do they form and grow upon the water, that perhaps observers in general rarely witness them. It is, however, easy to study the wonderful formation, growth, multiplication, and eventual merging together of the myriads of tiny discoidal star-like and other ice crystals, which in the wintertime change the liquid water into crystal sheets or masses. The marvelous "alchemy" or mechanism of ice formation, which, as if by magic, converts a fluid into a seemingly structureless solid, can be seen to advantage only under just the right conditions of light, position, etc., and unfortunately nature unassisted rarely furnishes such.

The whole process, however, can easily be watched upon and beneath the surface of a water pail or dish holding water in process of freezing, if the vessel is set in front of a window and a large piece of looking-glass placed flat down on the bottom beneath the water. The water may be occasionally stirred very gently, and such crystals as form from time to time may be removed.

Ice crystals should possess a very great interest for the crystallographer and student of nature, for, as noted further on, certain types pass thru most strange and unusual phases of growth. Moreover, they are so very easily seen and studied if viewed under the proper conditions of light, etc., that they perhaps furnish the best opportunities that occur in nature for the general study of crystal forms. They should possess an added interest as crystallographic subjects, because they can very easily be subjected, while forming and growing, to diverse artificial and natural conditions, such as relate to temperature, location and environment; and thus they afford a means of ascertaining the effects that these various conditions have on the forms and habits of growth of crystals. Tho easily observed and studied, they are most difficult objects to photograph. The writer undertook the task of photographing them during the winter of 1904-5, but had poor success; and only after repeated failures succeeded in securing good photographs of them while floating and growing upon the surface of the water during the winter of 1905-6. Possibly these here given may be the first series of photographs that adequately portrays the form and structure of ice crystals of this character, while in actual process of formation and growth on the surface of liquid water.

(56) The merging together of crystals into massive ice.

The forms and habits of growth, and the mode of arrangement of the individual crystals of ice, as well as the manner in which they merge and freeze together to form sheets and masses of solid ice, necessarily vary in different cases, and in the case of different types under varying conditions of temperature, environment, etc. The solid ice itself, when new, rarely discloses the manner in which it was formed, or the forms and manner of arrangement of the many individual crystals of which it is composed, because, in general, those crystals are so completely and perfectly merged together during the process of freezing that in many cases every trace of their forms, outlines, and arrangements within the ice is completely obliterated. In most cases ice crystals grow outward from a given constituted ice nucleus, by attracting and drawing water molecules to their apices and edges. The only exception seems to be in the case of the formation of ice columns in peaty or gravelly soil.[6] Such seem to grow in an inverse order, thru additions drawn upward thru the pores of the soil and deposited beneath the bases of the columns.

[6] See article by Prof. Cleveland Abbe in the American Meteorological Journal, April, 1893, vol. ix, pp. 523-525; reprinted in the Weather Review for April, 1905, vol. xxxiii, pp. 157-158.

The manner in which, in general, solid films or sheets of ice of considerable thickness are formed upon the surface of pond, and of gently flowing brook water, consists, in many cases, of the following steps:

1. The formation of a very thin film of ice upon the surface of the water, thru the formation and growth and merging thereon of myriads of needle-shaped, discoidal and branch-like crystals and ice flowers.

2. The gradual thickening of this film thru additions from below, deposited upon its under surface.

3. The formation on the under side of such an ice film, and the growth downward into the water beneath, of various needle-shaped and branch-like ice crystals.

4. The formation, within the free water beneath such a film, of ice flowers and other crystals which rise to the under surface of the film, and grow within the compartments that exist between the downward-growing crystals and branches.

5. The continual formation and growth of new nuclei, and the continuation of the growth of the older crystals until all merge and freeze together and form a second and thicker solid ice film below, but merging with the original one. During long continued cold, this process repeats itself from time to time, until solid ice sheets of great thickness are formed. Brook and river ice, however, as formed over swiftly flowing water, grows in thickness thru accretionary processes, i. e., by liquid particles freezing to the lower surfaces of the ice, without the formation of typical ice crystals.

(57) The structure of old ice.

From the foregoing it will be seen that, in general, a mass of solid ice is not formed wholly, and perhaps not mainly, thru the formation and merging of a vast number of tiny, symmetrical flower-shaped crystals, but rather thru the growth and merging of diverse types of crystals, and of segments of such, differing greatly in size, form, and structure. When closely examined, old ice, as a result of slight internal melting, or of changes of structure due to its being repeatedly subjected to cold and changes of temperature, often reveals traces of its former open crystalline "pre-solid" character. Such old ice presents faint evidence of a cellular or honeycomb-like structure, the cell walls being mainly normal to the surface of the ice. Photograph No. 230 B shows the cellular structure of such old ice; the cells and cell walls are irregular in form and arrangement.

In general, the long, slender air tubes, which are the only conspicuous internal feature of such ice, are arranged perpendicularly to its surface, but ofttimes parallel to and at the lines of intersection of two or more of the faintly outlined cell walls. Their perpendicular arrangement may be due, in part, to the fact that in general the longer radii of the crystals of which such ice is formed also lie perpendicular to or at angles of 60° with the surface of the ice. Yet the main cause, in most cases, must be attributed to the fact that such ice sheets undergo lateral expansion and contraction during and subsequent to solidifying. Such internal stresses tend to squeeze the air into the ice along the lines of fracture and of least resistance, i. e., into the so-called cell walls, or their points of intersection.

(58) Frazil ice.

The so-called frazil ice, or mush ice, of rivers and flowing streams forms only during extreme cold and only when the whole body of water within such streams or rivers becomes chilled to the freezing point. Multitudes of tiny discoidal and other ice crystals form and grow both upon and beneath the surface of such chilled flowing water. The water currents always present within flowing water tend to keep many crystals submerged, and to draw surface crystals downward into the water, and to cause them to diffuse themselves therein. As a result of this forced submergence myriads of them come into contact with submerged stones, soil, etc., upon the sides and bottoms of such flowing streams, and attach themselves thereto and to one another, and grow therefrom.

(59) Anchor ice.

The so-called anchor ice is in many cases doubtless due to the same causes. But possibly in some cases ice-crystal nuclei may form and grow in the first instance directly upon and from submerged stones and objects lying upon the bottoms of such streams. The primary cause of the formation, or rather retention, of masses of frazil or anchor ice at the bottom and sides of flowing rivers is doubtless due to radiation of heat from the bottom upward, as set forth by Prof. Howard T. Barnes in his very interesting and instructive book, "Ice Formation".[7]

(60) Ice flowers.

Tho in general the process of merging and solidification destroys all visible traces of the forms and outlines of the individual crystals, of which solid masses of ice are formed, the crystals may in many cases be rejuvenated and made visible again by the proper treatment. Tyndall's method, whereby the ice is subjected for a time to the gentle heat of the sun's rays, causing a very slight internal liquefaction to take place, will generally reveal them anew. This gentle heat operates in such a way as to liquefy the special less dense portions of the ice lying between the crystals proper, and hence brings them into view again. Star-shaped ice crystals, those termed "ice flowers" by Tyndall, come out most plainly within blocks of such sun-laved ice. They appear most frequently within pond and lake ice, but sometimes also within river and brook ice. The ice flowers that are found so embedded within the solid ice vary greatly in size, form, complexity, and symmetry, but all, or nearly all, lie so that their tabular planes are parallel to the surface of the ice. They differ in one important respect from ice flowers newly formed upon the surface of freezing water, in that large air bubbles form their nuclei, whereas the latter possess none.

In most cases, after the ice flowers are made visible as heretofore described, if the ice be then subjected to intense cold for a time the contraction of the ice will cause the nuclear air bubbles to diffuse themselves outward in a nebulous aspect around the whole radius of the ice flowers, and cause the destruction of the latter, as shown in photograph No. 232. The author has made but few photographs of embedded ice flowers. No. 231 is the only one thought best to reproduce; it shows some embedded in brook ice.

Fortunately other students of ice, notably Prof. Benjamin W. Snow of the University of Wisconsin, and Prof. H. Schoentjes of Université de Gand, have made a large number of excellent photographs of embedded ice flowers. Professor Snow has kindly furnished a few of his photographs to be used to illustrate the beautiful forms of the embedded ice flowers. (See Nos. 228, 229 A, 229 B.) Professor Schoentjes has made an extended study of these and of ice formation, and has written a very interesting and helpful book treating of them.[8]

(61) Structure of pond and lake ice.

There is much of interest about the structure of pond and lake ice, aside from that relating to the ice flowers embedded therein. The forms and arrangement of the air tubes therein, and the changes these and the structure of the ice undergo under the influences of sunlight and mild weather, are of especial interest. In general, pond and lake ice, when viewed horizontally, presents a banded appearance. This is due to the fact that some sections or layers are thickly threaded with air tubes, which give a white, milky appearance to them; while others contain few or no air tubes, and hence are very clear and transparent. This banded appearance shows in our photograph of pond ice, No. 230 A. The upper layer usually consists of white, opaque snow, and water ice, and commonly the layers

[7] Ice Formation, by Howard T. Barnes of McGill University, Montreal, Canada. Published by John Wiley & Sons, New York, U. S. A. 1906.

[8] Fleurs de la Glace, by Prof. H. Schoentjes, Université de Gand.

containing most air tubes lie within the upper half of a given section of ice. The presence or absence of air tubes within ice is doubtless largely due to the rapidity of the rate of the growth of the ice. All things being equal, ice that forms rapidly and during intense cold will contain many air tubes, while conversely, ice that forms slowly will possess but few air tubes. Ice that forms by accretionary processes over swiftly flowing water contains but few air tubes. The forms and sizes of the air tubes within the pond and lake ice vary greatly from one section or layer to another. Some layers may contain only long and slender tubes, others cigar-shaped ones, while others may contain small or large, oval or round tubes. (See photograph No. 230 C). They seem to be subjected to great pressure, for they are often foreshortened as tho by intense stress. This seems proved from the fact that air tubes of a given size, after the ice has been subjected for a time to sunlight or to mild temperatures, are found to extend farther than in the first instance, owing to the fact that a slight internal melting has resulted in revealing the original former dimensions of the tubes as they existed before internal pressure constricted them. (See photograph No. 230 D.)

(62) Various ice-crystal forms.

Ice crystals develop largely if not wholly upon thin tabular or discoidal planes, and a large proportion form and grow in segmental form only. The great majority assume branch-like, leaf-like, or needle-like forms, but complete crystals or "ice flowers" having six leaf or branch-like rays, arranged symmetrically like those of snow crystals, are not rare. Ice crystals seem rarely or never to assume the form of the solid or hollow six-sided column, or to develop in a trigonal manner. They nearly all resemble one another in this, that their outlines are soft and curving, rather than hard, abrupt, and facet-like, and in this they vary markedly from most snow crystals. The primary or germ forms of each of the several types of ice crystals are at first very dissimilar in form one to another; but as they develop, they tend to grow more and more in a common branch-like manner, and hence when mature resemble one another more closely than at birth.

(63) First formation of ice crystals.

Ice crystals when first formed, tho free from air tubes and inclusions, are yet lighter than water, and if unattached to anything always rise to the surface and remain resting thereon, usually with their tabular planes lying parallel to the surface. In general, germ ice crystals form more slowly in perfectly calm than in slightly agitated water. When the whole of a body of water becomes chilled to a certain degree, a gentle stirring of the water, a jar, or a rocking of the receptacle containing it causes myriads of germ crystals to form with amazing suddenness both upon and beneath the surface of the water.

(64) Diversity of types.

Perhaps the most surprising fact in connection with the formation and growth of ice crystals is this, that so many diverse types form and grow, each perhaps in a different manner, at the same time within or upon a given body of water, and apparently under the same identical conditions of temperature, air pressure, environment, etc. Photograph No. 262 shows crystals of various types, formed and growing in the manner described. Changes of temperature seem not to lead to either a marked increase or a decrease in the number of different germ types forming at a given time; tho cold hastens and milder temperatures retard the passage of crystals from one stage of growth to another, and seem to influence the exterior character (i. e., whether it be frail and branch-like, or otherwise) of the superstructure that grows outward from immature crystals of each of the various types. This seems to forge one more link in the chain of proof that, tho exterior conditions and environment exert a great influence in determining and modifying crystallic forms and structures, yet there is a mysterious something—individuality, or whatever it may be called—inherent within the crystals themselves, that enters into the problem of form determination. This exerts an influence causing the parent or germ crystal to impart its own peculiar habits of growth to the molecules of water that such parent crystals, as growth progresses, draw to and incorporate upon and around themselves, in the form of new growth.

(65) Merging and thickening of ice crystals.

Ice crystals of whatever type freely merge and freeze together, one to the other. They are, when first formed, and for some time thereafter, exceedingly thin as regards tabular thickness, hardly thicker in fact than thin paper, probably having a thickness between the one hundred and fiftieth of an inch and the two hundred and fiftieth of an inch. They gradually, but very surely, become thicker with age and increase in size.

(66) Variation in size.

Ice crystals, even as first formed, vary greatly also one from another in greater diameter. Many ice-crystal nuclei are mere specks, with diameters of less than one-fiftieth of an inch; while others, when they come into visible existence, possess forms of considerable size, one-fourth of an inch or even more in greater diameter. Intense cold seems to favor the formation of tiny nuclei, and a milder degree of cold that of larger nuclei. Intense cold seems to favor branch-like, and a mild temperature solid growth. Ice crystals vary much more markedly as to the ratio of thickness to diameter than do snow crystals.

Germ ice crystals, floating and growing upon the surface of calm water, seem to draw their growth material almost wholly from a thin film of chilled surface water. They seem to draw little from below. That this is the case is proved by the fact that whenever two or more crystals lie close together, or even some distance apart, growth occurs fastest and in the greatest degree upon the portions of each crystal that lie the farthest away from the neighboring crystal, or crystals. (See photographs Nos. 264 and 265.) If it were the case that they drew their growth supplies from below, their contiguity would make but little difference in the rates of growth of the crystals so situated, because the source to be drawn from would be relatively limitless.

[To be continued.]

METEOROLOGICAL STATIONS IN SOUTHERN NIGERIA.

C. FITZHUGH TALMAN, Assistant Librarian.

The past decade has witnessed an extraordinarily rapid extension of the network of meteorological stations in Africa. The distribution of stations eight or ten years ago is shown on the chart which forms the frontispiece of Bartholomew's Atlas of Meteorology (1899). At that time meteorological observations were well organized in Algeria and south Africa, and work had begun, in a small way, in several British colonies, under the supervision of the British Association Committee on the Climatology of Africa. A few widely scattered stations existed in the Congo State.

In 1900 a general meteorological service was organized in Egypt, and its network of stations has been pushed southward until now it includes the whole basin of the upper Nile, in the heart of central Africa, and adjoins the meteorological system of British East Africa. The latter was organized as an independent service about three years ago, and this year, 1907, embraces about 50 stations of all orders. The British Central Africa Protectorate had, in 1905, a network of 40 stations. Southern Rhodesia has 48 stations, nearly all of which are less than ten years old. (See map in the MONTHLY WEATHER REVIEW for March, 1907, p. 124.) The Transvaal had 375 stations in operation during the year 1906, of which 32 were equipped with barometers. The Orange River Colony had, in 1905, 9 second-order stations and 74 rainfall stations.

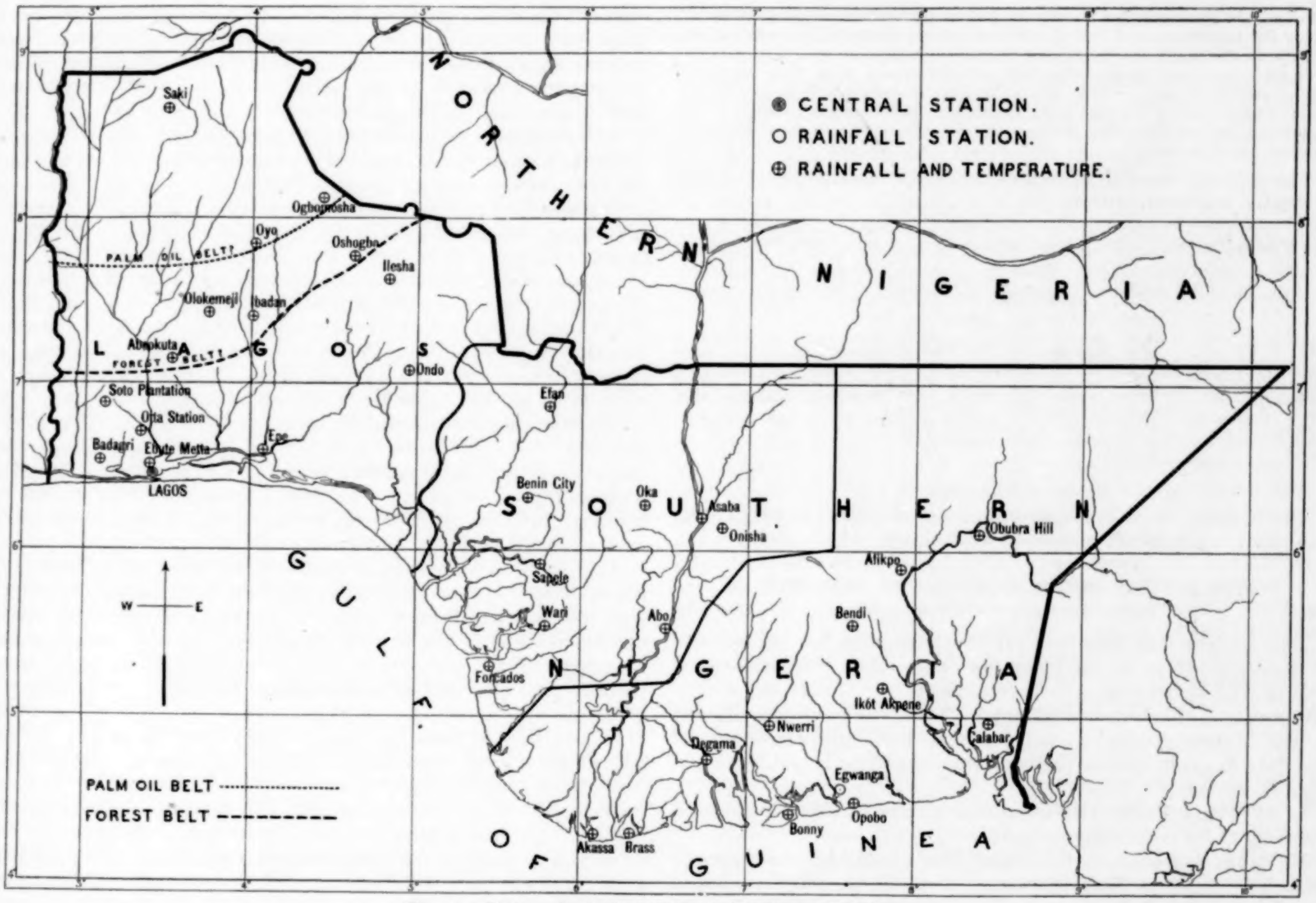

FIG. 1.—Meteorological stations in Southern Nigeria.

Meteorology has made especially rapid progress in the German possessions and protectorates, and the German observations have been very fully published—especially in Danckelman's Mitteilungen and the Überseeische Beobachtungen of the Deutsche Seewarte. From a new work by Doctor Fitzner on the rainfall of the German colonies[1] we obtain the following statistics of rainfall-reporting stations in Germany's African possessions. The enumeration, which refers to the end of 1905, includes a considerable number of stations that had been discontinued prior to that time; however, it affords an indication of the extent of territory from which climatological data are available.

Colony.		
Kamerun	30	No. of stations from which rainfall data are available.
Togo	21	
German Southwest Africa	71	
German East Africa	84	

Of the French colonies, besides Algeria, already mentioned, Tunis has a well-organized meteorological service, which in 1903 embraced 34 stations. More recent figures are not at hand.

The British colonies in west Africa include a number of meteorological stations, some of long standing, whose observations have been published mainly in the reports of the British Association and the blue books of the Colonial Office. A map of the stations in the Gold Coast Colony appeared in the MONTHLY WEATHER REVIEW of September, 1906, p. 425. We are now able, thru the courtesy of Mr. E. P. Cotton, director of surveys at Lagos, to present a chart showing the location of meteorological stations in Southern Nigeria (Fig. 1). Mr. Cotton also sends the following particulars regarding the meteorological system of Southern Nigeria, which is under the direction of the department of surveys, with headquarters at Lagos.

There are at present 36 meteorological stations in the colony of Southern Nigeria which are classified under three headings, denoting the Eastern, Central, and Western Provinces, to which they belong.

(*a*) In the Western Province there are Lagos, the central station, which has an observatory, Ebute Metta, Badagri, Epe, Olokemeji, Ondo, Ibadan, Oyo, Saki, Ilesha, Abeokuta, Oshogbo, Soto Plantation, Otta Station, and Ogbomosha, all of which are rainfall and temperature stations.

(*b*) In the Eastern Province we have Bonny, Egwanga, Calabar, Bendi, Ikot Akpene, Obubra Hill, Brass, Degama, Nwerri, Opobo, Afikpo, and Akassa; all these are rainfall and temperature stations except Egwanga, which is at present a rainfall station only, but we hope to equip it as a rainfall and temperature station shortly.

(*c*) The Central Province furnishes us with the following, viz: Forcados, Sapele, Asaba, Benin City, Efan, Onisha, Wari, Abo, and Oka, all of which are rainfall and temperature stations.

The Lagos Observatory, which is the principal station, is well equipped with barometer (Kew pattern), barograph, minimum on grass, maximum in sun; rain-gage with receiver and measuring glass; maximum mercurial thermometer, minimum spirit thermometer, and ordinary thermometer, hygrometer, besides a Dines anemometer, and other costly instruments for astronomical purposes.

The remaining or second-class stations have a maximum thermometer, minimum thermometer, rain-gage with receiver and measuring glass, and two ordinary thermometers.

Very few of these latter stations have maximum in sun and minimum on grass as well.

At the Lagos Observatory observations are made twice daily, namely, at 9 a. m. and 3 p. m., respectively, whilst only at 9 a. m. at the other stations, in order to suit the convenience of the various observers and also in consequence of their not having many instruments.

[1] Fitzner, Rudolf. Die Regenverteilung in den deutschen Kolonien. Berlin: Heimann Paetel. 1907.

These observations are taken at Lagos by the meteorological clerk, under the supervision of the director of surveys; and at the outstations mostly by the medical officers and district commissioners.

These observers in the districts are furnished with two meteorological registers each, which are to be sent alternately to Lagos at the close of each month, so that the records may be compiled there, and the register is also returned in a few days, so that the continuity of the records may not be interrupted.

The rainfall record registered in each station during the previous year stands thus:

Western Province.		Eastern Province.		Central Province.	
Station.	Inches	Station.	Inches.	Station.	Inches.
Lagos	74.76	Bonny	142.26	Forcados	98.23
Ondo	54.59	Egwanga	251.49	Sapele	106.69
Ibadan	46.40	Calabar	156.64	Asaba	44.27
Olokemeji	40.90	Bendi	87.08	Benin City	93.30
Badagri	58.34	Onisha	58.21	Efan *	27.17
Epe	60.23	Obubra Hill *	3.50		
Oshogbo	47.95	Nwerri *	80.14		
Oyo	46.60	Afikpo	90.77		
Saki *	34.32				

* Records incomplete.

The highest rainfall, 251.49 inches, was registered at Egwanga and the lowest, 40.90 inches, at Olokemeji.

THE ROYAL METEOROLOGICAL SOCIETY.

[Reprint of a circular issued by the society.]

The society was founded for the promotion of the science of meteorology in all its branches on April 3, 1850, under the title of The British Meteorological Society. On its incorporation by royal charter, on January 27, 1866, the name was altered to The Meteorological Society; and in 1883, by permission of Her late Majesty Queen Victoria, it became The Royal Meteorological Society.

In 1904 His Royal Highness the Prince of Wales honored the society by becoming its patron.

Meetings are held on the third Wednesday in each month from November to June inclusive—those in the evening being usually (by permission) at the Institution of Civil Engineers, and those in the afternoon in May and June at the society's rooms, 70 Victoria street. These occasions afford an opportunity for social intercourse between those interested in meteorology, tea being served after the evening meetings or before the meetings in the afternoon.

Exhibitions of new and special classes of meteorological instruments, as well as of diagrams, charts, and photographs, are held from time to time. Popular lectures on meteorological subjects by eminent authorities are also arranged for on special occasions.

The papers read at the meetings, together with the discussions, in which every fellow is entitled to take part, are printed in the Quarterly Journal, which also contains notes, correspondence, notices of recent publications, and the titles of such papers as appear to be of general interest bearing on meteorology in the periodicals which are received in the society's library. It thus serves to keep the fellows residing at a distance from London in touch with the meteorological work of the world.

In 1874 the society commenced the organization of a series of second-order stations, at which observations of pressure, temperature, humidity, rainfall, and wind are made on a uniform plan so that the results may be strictly comparable. In addition to these, another class of stations, termed climatological, was organized on January 1, 1880, at which the observations, altho of equal accuracy, are less exacting. These stations, which number about 100, are well distributed thruout the country; they are regularly inspected on behalf of the society, and the results of the observations are published in the Meteorological Record.

In 1874 a conference on the observation of periodical natural phenomena was organized, and as the result of their deliberations the society instituted the series of phenological observations which have been continued since that time, first under the superintendence of the late Rev. T. A. Preston, and since 1888 under that of Mr. E. Mawley.

A lightning rod conference was organized in 1878, which in 1882 published a valuable report embodying a code of rules for the erection of lightning conductors.

The society has initiated and carried out various scientific investigations, of which the following may be mentioned: (1) systematic investigations of the thunderstorms of 1888 and 1889, and the classification of the various forms of lightning; (2) inquiry into the phenomenon of the Helm Wind of Cross-fell, Cumberland; (3) investigation into the relation between Beaufort's scale of wind force and the equivalent velocity in miles per hour; (4) the investigation of the meteorological conditions of the upper air by means of kites.

The Symons gold medal, founded in 1901 in memory of the late Mr. G. J. Symons, F. R. S., is awarded biennially by the council for distinguished work done in connection with meteorological science. The medal was presented to Dr. A. Buchan, F. R. S., in 1901; to Dr. J. Hann, of Vienna, in 1903; and to Lieut.-Gen. Sir R. Strachey, F. R. S., in 1905.

The society possesses a valuable meteorological library of about 8700 volumes, 12,000 pamphlets, 200 maps and charts, and 800 manuscripts, unequalled by any collection of works on this science in the world. It also possesses a unique bibliography, which contains the titles of all books, pamphlets, papers, and articles bearing on meteorology, in all languages of which any notice can be found.

In addition to these, there is a large and interesting collection of photographs and lantern slides illustrating meteorological phenomena and instruments.

With the view of advancing the general knowledge of meteorology, promoting an intelligent public interest in the science, and making the work of the society more widely known, a lecturer has been appointed to act in cooperation with scientific societies, institutions, and public schools in various parts of the country. Exhibits of selections from the collection of photographs, drawings, diagrams and charts illustrating meteorological phenomena, and also various patterns of instruments used for observations, are shown, under the charge of a member of the staff, at gatherings of local scientific societies, or on other occasions when they are likely to prove of interest.

Candidates for the fellowship are elected by ballot, after recommendation by three fellows, one of whom must certify from personal knowledge. Ladies are eligible for the fellowship. Fellows are entitled to the designation, F. R. Met. Soc.

Fellows have the privilege of attending the meetings and introducing visitors; they have the free use of the library and receive gratis the Quarterly Journal, the Meteorological Record, and the other publications of the society. The council of the society is elected by the fellows annually, and reports to the fellows at the annual general meeting.

The library and offices at 70 Victoria street, Westminster, are open daily between the hours of 10 a. m. and 5 p. m., excepting on Saturdays, when they are closed at 1 p. m. Fellows are always welcomed at the society's rooms, and the office staff is always ready to assist in supplying any meteorological information which is desired.

Every fellow pays an annual subscription of £2, or a life composition of £25, and in addition an entrance fee of £1. For fellows elected in November and December the payment of the first subscription exempts them from any contribution for the next succeeding year.

In addition to the fellows, there is a class (limited to 20) of honorary members, which is confined to distinguished foreign meteorologists.

All communications should be sent, and all money contribu-

tions paid, to the Assistant Secretary, Mr. W. Marriott, at 70 Victoria street, S. W.; checks being crost "the Bank of England".

Foreigners are eligible to membership in the society, and it is desired to give the society an international character by adding as many as possible to its list of members. The secretary has deposited a number of blanks for nomination with the Editor of the MONTHLY WEATHER REVIEW, and adds: "We always welcome fellows from any part of the world".

THE CHRISTMAS METEOR OF 1873 AT WASHINGTON, D. C.

By Prof. HENRY A. PECK. Dated Syracuse University, Syracuse, N. Y., November 16, 1907.

At the meeting of the Philosophical Society of Washington, D. C., on the 27th of December, 1873, its attention was called by Dr. Peter Parker to a remarkable meteor which had been seen on Christmas eve. The topic excited considerable interest as several members of the society had witnessed the flight of the meteor, and a committee consisting of Dr. Peter Parker, W. L. Nicholson, and Cleveland Abbe was appointed to collect data. The report of this committee was read April 7, 1877, and was published in the Bulletin of the Philosophical Society of Washington for that year. Some time since the Editor kindly called my attention to the report and suggested that further work on some phases of the subject might be useful. In what follows, the reader is supposed to have access to the report in question, which is readily accessible to interested parties.

THE POINT OF DISAPPEARANCE OF THE METEOR.

At twenty-four stations records were made of the disappearance of the meteor. Many of these records are very crude, and when the directions given by the remainder are plotted on a map, it at once becomes apparent that many of the persons making the observations did not see the meteor at the time of extinguishment, as others situated farther along its track continue to report it. This brings us at once face to face with one of the difficulties that confronts any one having to do with observations made by persons unused to such work. The separation of the wheat from the chaff often calls for more skill and judgment than any other feature in the process of locating the tracks of meteors. Undoubtedly the observers generally see the meteor at the points noted, but interposing trees, buildings, and other obstructions cut off the view, and they do not realize the necessity of noting this fact. An example is found in the Washington observations. Four observers report that the meteor disappeared within a degree or two of due west, and only one mentions any obstruction to vision. On the other hand, Prof. E. S. Holden, at the Naval Observatory, made a careful determination and found the disappearance at south 68° west, with an altitude of less than 5°. This determination is verified by the fact that the meteor was reported at Harpers Ferry and Appomattox to have azimuths differing by almost exactly 180°. After a somewhat careful study of the materials, I have made the determination of the end point depend upon the following observations, the longitude of the observer being noted with reference to the dome of the Capitol at Washington:

Station.	Longitude.			Latitude.		Azimuth.			Weight.
Number.		°	′	°	′		°		
14	E.	0	05	39	35	S.	33	W.	1
28	W.	0	02.5	38	54	S.	68	W.	3
40	W.	1	51	37	20	N.	25	E.	1
45	W.	0	43	39	18	S.	22	W.	1

Station 28 was occupied by Prof. E. S. Holden of the Naval Observatory. I have thought that his superior training in astronomical observation should entitle his record to much greater weight than could be accorded to that of observers who were deficient in this training.

It is evident that if the end point had been accurately observed at each station, the vertical planes corresponding to these azimuths would cut each other in a common line passing thru the zenith of the place where the meteor was extinguished. On account of the great errors with which meteor observations are always affected this will scarcely happen, and therefore we are called upon to determine the most plausible position of this line. A method of solution is given by Bauschinger in his "Bahnbestimmung der Himmelskörper" and this method has been followed, with the result that the geographical coordinates of the point are

Longitude 0° 57.8′ west

Latitude + 38° 42′.

The theoretical probable error of the equations producing these coordinates is very small, and the position satisfies very closely the observation made at Danbury, Conn., as it is recorded on page 144. Professor Holden determined the altitude at disappearance to be 4° 45′ or less. Taking into account the curvature of the surface of the earth, we may easily derive from this that the disappearance took place at 4.8 miles from the surface. That the meteor came comparatively close to the surface is also established by other evidence. To the observer at Newcastle, Del., it was lost in the haze of the horizon. At Milford, Del., it disappeared "where the sun set". At Richmond, Va., it was followed to 9° 30′ altitude, and the observer "did not see the end". At Woodstock, Va., about 25 miles away, the altitude was estimated at 20°–25°, the lower altitude corresponding to 9 miles. In what follows a mean, 7 miles, has been chosen and used.

THE POSITION OF THE RADIANT.

When the end of the flight is known, we may find the position of the radiant from the mutual intersections of the great circles past thru the end point and any other point in the flight. Each station will furnish an equation, and the least-square solution of these equations will give the most plausible position of the radiant, or point from which the meteor would seem to approach an observer situated at the end of the flight. The observations that I have used are as follows:

Station.	Latitude.		Longitude.			Altitude.	Azimuth.		
Numbe .	°	′	°	′		°			
1	41	20	3	35	E.	30	S.	46°	W.
6	39	38	1	20	E.	60		S.	
20	39	9	0	2	E.	50		S.	
23	38	54	0	1	E.	45	S.	70°	E.
26	38	54	0	0		60		S.	
30	38	48	0	3	W.	90		.....	
31	38	53	0	13	W.	75		S.	
34	38	40	0	26	W.	90		.....	
40	37	20	1	51	W.	40	N.	55°	E.
41	38	59	0	53	W.	70	N.	67½°	E.
43	38	50	1	31	W.	45		E.	
48	38	56	3	9	W.	45		E.	

With regard to Station 1, Danbury, Conn., there is some ambiguity in the record. I have interpreted it to mean that the course of the meteor made an angle of 25° with a vertical circle.

The following table may next be constructed:

Station.	a		δ		a^1		δ^1	
Number.	°	′	°	′	°	′	°	′
1	327	8	−25	35	353	4	− 6	50
6	318	24	−18	52	29	41	+ 9	38
20	321	43	−20	2	28	23	− 0	51
23	312	44	− 6	31	71	47	+14	45
26	312	57	− 6	37	28	21	+ 8	54
30	308	57	− 0	33	28	18	+38	48
31	316	42	− 6	57	28	8	+23	53
34	306	20	+13	5	27	55	+38	40
40	164	35	+48	2	95	12	+47	39
41	13	22	−37	50	67	17	+43	46
43	95	44	− 2	56	78	55	+26	19
48	105	19	+ 9	38	77	19	+26	23

Here α and δ are the right ascension and declination of the point of disappearance as seen from the different stations, and α^1 and δ^1 are the right ascensions and declinations computed from the data given above.

From these right ascensions and declinations the longitude of the node, and the inclination of each of the great circles to the equator may be found as follows:

Station.	Longitude of node. N.		Inclination. I.	
Number.	°	′	°	′
1	201	6	139	25
6	185	21	157	37
20	210	33	158	37
23	156	24	165	15
26	164	5	167	27
30	129	37	140	38
31	150	12	152	25
34	109	38	141	2
40	40	27	53	20
41	37	37	62	8
43	274	10	28	0
48	298	16	52	52

The condition that the radiant shall lie on these great circles is exprest by the equation—

$$\sin N \sin I \cos D \cos A - \cos N \sin I \cos D \sin A + \cos I \sin D = 0,$$

where A and D are the equatorial coordinates of the radiant.

Forming these equations and solving them by the least-square method, there results

$$A = \quad 66° \ 55'$$
$$D = +29° \ 51'$$

When these values are substituted in the original equations, the residuals for several of the stations are found to be rather large. As it seemed possible that these might produce a sensible error in the results, the unknown quantities were again determined from equations not open to this objection, with the result

$$A = \quad 63° \ 40'$$
$$D = +31° \ 17'$$

When it is remembered that the observations are in general only estimates, the close agreement in these two results gives confidence in their substantial accuracy.

THE COURSE OF THE METEOR THRU THE ATMOSPHERE.

By the well-known formulas of spherical astronomy, this right ascension and declination of the radiant may be changed into azimuth and altitude. The result shows that, as viewed from the point of disappearance, the bearing and angular height above the horizon of the point from which the meteor appeared to come are

Azimuth S. 86° 55′ E.
Altitude 56° 27′.

It will be noticed that this course differs by nearly 30° from that laid down in the bulletin to which reference has been made. The observers at Washington saw the meteor to the south, and this is also the report from Milford, Del.; while to the observers at Woodstock and Buckhannon it seemed nearly to follow a vertical circle. As usual there is much confusion in the notices, but those that apparently deserve the most confidence seem to bear out the course indicated.

The most difficult results to obtain from the observations have been the data needed in order to compute the velocity thru the atmosphere. If the azimuths recorded by Mr. Inman, of Washington, D. C., and by Mr. Christian, at Appomattox Court-house, are plotted on the map in the bulletin, they will be found to intersect very near the mouth of the Choptank River, on the eastern shore of Chesapeake Bay. This point of intersection lies on the track of the meteor as traced above, and it is here that I am inclined to place its first appearance. As to the height of this point above the ground we have the following data:

	Miles.
Danbury, Conn.	138
Mercersburg, Pa.	112
Newark, Del.	127
Newcastle, Del.	150
Appomattox Court-house, Va.	134
Woodstock, Va.	120
Average	130

While this great elevation is by no means unprecedented, yet it is by no means common. Corresponding to it, the length of the flight may be taken as 154 miles. As usual, the evidence as to the duration of the flight is very weak. The authors of the report estimated it at not less than three nor more than five seconds. If we take the mean of these estimates, the velocity was 38.5 miles per second.

THE ORBIT WITH REGARD TO THE SUN.

The computation of the orbit in space proceeds according to well-established principles of theoretical astronomy. From the data contained in the Nautical Almanac, it is found that the longitude of the apex of the earth's motion was 183° 15′. When the radiant point, as given above, is freed from the effect of the attraction of the earth and from the effect of its motion in space, the position of the true radiant point or position in space from which the meteor actually came is found to be

λ (celestial longitude) 50° 47′
β (celestial latitude) + 6° 26′

and its velocity about fifty miles per second. It was following and overtook the earth, the angle between its path and the direction to the apex being 132°. The elements of the orbit with regard to the sun are

Ω (longitude of ascending node) 273° 22′
i (inclination to ecliptic) 9° 28′
π (longitude of perihelion) 150° 12′
log q (logarithm of perihelion distance) 9.7937
log e (logarithm of eccentricity) 0.6329

A PERSISTENT METEOR TRAIN OBSERVED AT ALBANY, N. Y.

By Prof. HENRY A. PECK. Dated Syracuse University, Syracuse, N. Y., October 22, 1907.

During the early twilight of Sunday evening, February 10, 1907, a large meteor was seen in the general direction of the setting sun by residents of Albany, N. Y., and the surrounding territory. Snow squalls had been frequent during the afternoon, and, on this account, in spite of the exertions of Mr. G. T. Todd, the local forecaster of the Weather Bureau, only very meager accounts of the phenomenon were obtained. This is much to be regretted, as the meteor was attended by a train that persisted for fully a quarter of an hour, apparently drifting to the north. Mr. Robert E. Horton, of Albany, resident engineer ot the barge canal, was one of the observers, and has kindly furnished the following description:

Sunday evening, February 10, at 5:45 p. m., standard time, I chanced to look from a window facing the south. I was surprised to find the sky overcast with light, yellowish, fleecy clouds of a type which I have seen preceding a midsummer hailstorm. The edge of the cloud canopy was about ten degrees above the horizon when first seen, and underneath was a heavy bank of black clouds reaching about the same altitude. * * * The cloud canopy was lifting and drifting rapidly toward the north. When it had reached an altitude of forty-five degrees, I was surprised to see, about S. 20° W, a zigzag streak of bright gold, the lower end of which was lost in the reddish haze above and back of the cloud bank and at an altitude of about twenty-five degrees. The upper end was visible to the naked eye at an altitude of twenty-five to thirty degrees against a background of clear blue sky. I called my wife to watch while I procured a Lemaire night glass. On my return at 5:50 p. m., it had not changed form but had changed color to a fleecy white. The sun had set and the cloud canopy had lifted nearly to the zenith. The field glass showed it to be apparently a rather dense, clearly demarked band of cloud, which when first seen was illumined by the sun.

A sketch which I made on a scrap of paper, showing its appearance thru the glass, is inclosed. (See Fig. 1.) The glass revealed several

broken bands invisible to the naked eye, as shown at B, C. The band was particularly brilliant in the vicinity of A, and this portion remained visible until dark. It changed form but little, the change, if any, being in the way of foreshortening, indicating that it was drifting toward the north.

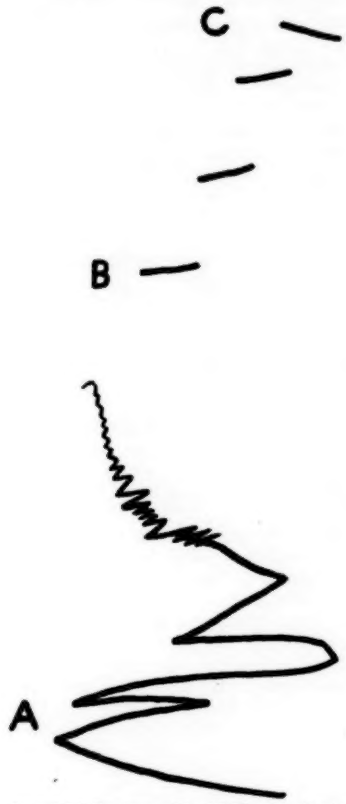

FIG. 1.—Meteor train of February 10, 1907, as sketched by Mr. Robert E. Horton.

Mr. M. W. Williams, of the Division Engineer's office in Albany, saw the phenomenon while in the city hall park.

It was 5:30 or 5:35 p. m. when I noticed the streak in the western sky, it being pretty nearly in the direction of the sun before the latter had set and against clear sky. At that time it appeared to be about as thick as the path of a flash of lightning, but in other points did not resemble one, being about this shape. (See Fig. 2.)

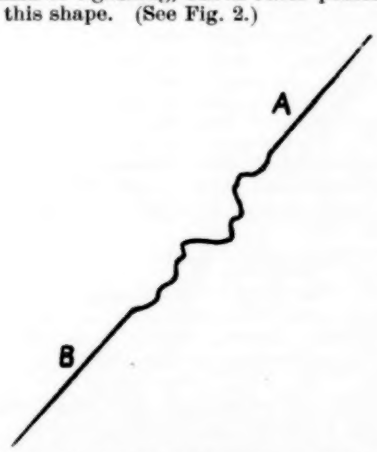

FIG. 2.—Meteor train of February 10, 1907, as sketched by Mr. M. W. Williams.

A and B appeared to be prolongations of each other and perfectly straight. The intervening crooked line had exactly the appearance of a cord which, after being stretched taut, is suddenly released at both ends. The streak began fading at once, and was invisible in about fifteen minutes, the middle of the crooked part being last visible.

Reports of a similar nature, but not so extensive, were received from the following persons:

William L. Stevens, Cobleskill; Mrs. J. W. Eaton, Albany; Mrs. Medora E. Davis, West Albany; Roy E. Crounse, Altamont; Harry Gaige, Altamont; Mrs. M. Orlup, Delanson; John Eddy, Glenmont.

Taking the horizontal refraction from the Poulkova tables, and the position of the sun together with the equation of time from the Nautical Almanac, the upper limit of the sun was tangent to the horizon at five hours and nineteen minutes standard time. It is, therefore, quite apparent from the known height at which meteor trains are apt to form that this one, from beginning to final disappearance, was still in full sunlight.

When the attempt is made to fix the path of the meteor and the limits of the train, the evidence is found to be quite meager. It evidently did not begin to attract attention, possibly on account of the bright twilight, until the appearance of the train. It is doubtful if any one saw the lower limit of the train on account of the condition of the sky. A canvass was made of all persons known to have seen the phenomenon, but while evidence was obtained confirming the accounts given above, the data for mathematical computation was very conflicting. The train was probably in the zenith in the vicinity of

Longitude 75° 30′ west of Greenwich,
Latitude 42° north,

at a distance of about a hundred miles from Albany, but no reports were ever received from that region.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

H. H. KIMBALL, Librarian.

The following titles have been selected from among the books recently received, as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies. Most of them can be loaned for a limited time to officials and employees who make application for them.

Baden. Zentralbureau für Meteorologie und Hydrographie.
Jahres-Bericht... 1906. Karlsruhe. 1907. 116 p. f°.

France. Association française pour l'avancement des sciences.
Compte rendu de la 35 session. Lyon 1906. Notes et mémoires. Paris. 1907. 1442 p. 8°.

Gironde. Commission météorologique.
Observations pluviométriques et thermométriques faites dans le Département de la Gironde de juin 1906 à mai 1907. Bordeaux. 1907. 49 p. 8°.

Hann, Julius.
Der tägliche Gang der Temperatur in der äusseren Tropenzone. B. Das indische und australische Tropengebiet. (S.-A. Denkschr. Akad. Wien. LXXXI. Bd.) Wien. 1907. 93 p. f°.

Herault. Commission météorologique.
Bulletin... Année 1906. Montpellier. 1907. 128 p. 4°.

Hesse. Grossherzogliches hydrographisches Bureau.
Deutsches meteorologisches Jahrbuch. Darmstadt. 1907. [13], 59 p. f°.

Kurz, Karl.
Die beeinflussung der Ergebnisse luftelektrischer Messungen durch die festen radioaktiven Stoffe der Atmosphäre. Dissertation... Giessen. 1907. 71 p. 8°.

Lange, Marcus.
Die Verteilung der Elektrizität auf zwei leitenden Kugeln in einem zu ihrer Zentrallinie symmetrischen elektrostatischen Felde. Dissertation... Giessen. Berlin. 1906. 14 p. f°.

Moedebeck, Hermann W. L.
Pocketbook of aeronautics. Translated by W. Mansergh Varley. London. 1907. xii, 496 p. 16.

Netherlands. Koninklijk nederlandsch meteorologisch instituut.
Onweders, optische verschijnselen, enz. in Nederland... 1905. Deel XXVI. Amsterdam. 1907. 125 p. 8°.

Pyrénées-Orientales. Commission météorologique.
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Rijckevorsel, [Elie] van.
Konstant auftretende secundäre Maxima und Minima in dem jährlichen Verlauf der meteorologischen Erscheinungen. Dritte und vierte Abteilung. Rotterdam. 1907. 24 p. f°.

Smithsonian institution.
Smithsonian meteorological tables. 3d rev. ed. Washington. 1907. lx, 280 p. 8°.

RECENT PAPERS BEARING ON METEOROLOGY.

H. H. KIMBALL, Librarian.

The subjoined titles have been selected from the contents of the periodicals and serials recently received in the Library of the Weather Bureau. The titles selected are of papers or other communications bearing on meteorology or cognate branches of science. This is not a complete index of the meteorological contents of all the journals from which it has been compiled; it shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau. Unsigned articles are indicated by a ——

American magazine of aeronautics. New York. v. 1. Nov., 1907.

—— International aeronautical congress, New York, 1907. p. 15–19.

Süring, Reinhard. Aerology in Germany. p. 27–29.

Geographical society of Philadelphia. Bulletin. Philadelphia. v. 5. Oct. 1, 1907.

Surface, G. T. Geography of Virginia. [Climate, p. 20–26.] p. 1–60.

Meteorological society of Japan. Journal. Tokyo. 26th year. Sept., 1907.

Tamura, S. T. A memoir of Prof. Diro Kitao (English). [With portrait.] p. 1–10.

Open court. Chicago. v. 21. Nov., 1907.

Daingerfield, Lawrence H. The evolution of climate. p. 641–643.

Nature. London. v. 76. Oct. 17, 1907.

—— International meteorological committee. [Account of Paris meeting, 1907.] p. 620.

Keeling, B. F. E. Upper air research in Egypt. p. 637.

Bonacina, L. C. W. Rain gage exposure and protection. p. 672–673.

Physical review. Lancaster. v. 25. Nov., 1907.

Barus, C. Condensation nuclei obtained from the evaporation of fog particles. p. 391–398.

McKeon, T. Frederick. The diurnal variation of the spontaneous ionization in air in closed metallic vessels. p. 399–421.

Popular science monthly. New York. v. 71. Dec., 1907.

Strong, W. W. Radioactivity of ordinary substances. [Radioactivity of the atmosphere, p. 530–532.] p. 524–535.

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Kavanagh, I. J. Stonyhurst college observatory, Lancashire, England. p. 291–296.

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Mill, Hugh Robert. The best form of rain gage, with notes on other forms. p. 265–274.

—— The climate of Eritrea, North-East Africa. [Abstract] p. 274.

Lovibond, Joseph W. On a method and apparatus for measuring fog densities. p. 275–278.

Capper, J. E. Note on a balloon struck by lightning. p. 279–285.

Capper, J. E. Kites struck by lightning, July 10, 1907. p. 285–286.

—— Balloon struck by lightning, July 22, 1907. p. 286.

Hooker, Charles P. The relation of the rainfall to the depth of water in a well. p. 287–293.

Child, Walter. The "step" anemometer. p. 295–298.

Rawson, H. E. Anticyclones as aids to long-distance forecasts. p. 309–310.

Science abstracts. London. v. 10.

S[immons], H. W. Influence of wind on the quantity of rain collected in a rain gage. [Abstract of article by A. Lo Surdo.] (Sept. 25, 1907.) p. 472.

H[ay], A. Lightning. [Abstract of article by C. P. Steinmetz.] [Estimate of voltage, etc.] (Oct. 25, 1907.) p. 543.

Scientific American supplement. New York. v. 64. Nov. 16, 1907.

Birdwood, George. The mechanism of the monsoon. The work of a mighty wind. p. 315.

Symons's meteorological magazine. London. v. 42. Oct. 1907.

Bonacina, L. C. W. On some of the causes and effects of atmospheric electricity. p. 169–174.

Bates, D. C. The study of weather phenomena. p. 177–179.

Tokyo mathematico-physical society. Proceedings. Tokyo. 2d ser. v. 4. no. 7. Aug., 1907.

Tanakadate, T. On the theory of the rainbow. p. 134–146.

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Störmer, Carl. Sur les trajectoires des corpuscles électrisés dans l'espace sous l'action du magnétisme terrestre avec application aux aurores boréales. p. 317–364.

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Lagrange, E. Première assemblée générale de l'Association internationale de sismologie. p. 369–375.

Solvay, Ernest. De la condensation électrique dans l'atmosphère. p. 395–409.

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Luizet, M. Observation d'un éclaire en chapelet. p. 780.

Mogimont. Station météorologique. Publication. No. 3.

Bracke, A. La trombe de Hallaer 20 août 1907. p. 45–48.

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Gallenkamp, W. Sur des mesures de l'evolution de la pluie. p. 169–172.

Okada, T. Vitesse de chute des gouttes de pluie. p. 172–174.

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—— Die Erdbebengebiete und volkanreihen Amerikas. p. 722–723.

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Berg, L. Ist Zentral-Asien im Austrocknen begriffen? p. 568–579.

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Knoche, Walter. Die äquivalente Temperatur ein einheitlicher Ausdruck der klimatischen Faktoren "Lufttemperatur" und "Luftfeuchtigkeit". p. 433–444.

Langbeck, K. Studie über Wirbelgewitter nach Beobachtungen am 20. Februar 1907. p. 444–453.

Defant, A. Die Abhängigkeit der diffusen Wärmestrahlung von der Jahreszeit. p. 461–465.

Exner, Felix M. Grundzüge einer Theorie der synoptischen Luftdruckveränderungen. p. 465–468.

—— Resultate meteorologischer Beobachtungen auf Campbell Island. p. 468.

Schmauss, A. Der Temperaturgang auf der Zugspitze und in der gleichen Seehöhe der freien Atmosphäre über der bayerischen Hochebene vom 22. bis 27. Juli 1907. p. 468–470.

Siegel, Franz. Regenmessungen an der Serra-Bahn (Paraná) im Jahre 1906. p. 470.

Brückmann, W. Harmonische Analyse des täglichen Ganges des Luftdruckes in Potsdam und Berlin. p. 470–472.

Hann, J. Ueber Angots Darstellung der jährlichen Periode des Regenfalles. p. 472–474.

Friesenhof, —. Gewitter und Sonnenflecken. p. 474–475.

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NOTE ON THE DIURNAL HEAT EXCHANGE IN A LAYER OF SNOW ON THE GROUND.

By T. OKADA.

[Reprinted from the Journal of the Meteorological Society of Japan, April, 1907.]

The earth accumulates solar heat during the daytime, and gradually loses the stored energy during the nighttime, so that there is a diurnal heat exchange in the upper layers of the earth's crust. The determination of the amount of this heat exchange in different kinds of soil is one of the interesting problems of meteorology. Already various memoirs on this subject have been published by several investigators. Among others, Dr. Theodor Homén, of the University of Helsingfors, made several

researches on the heat contents of such soils as humus, sand, and clay, and published the result of his discussion in his excellent treatise on the diurnal heat exchange in soil. Recently Prof. J. Schubert, of the Eberswalde Dendrological College, took up the subject, and completed Homén's investigation both in theory and observation, so that little remains for further researches.

In winter when snow covers the ground 1 or 2 meters deep, the daily heat exchange takes place in the upper layers of the snow, and the variations of heat content cease to be appreciable at a depth of a few decimeters. This exchange of heat in the outer layers of the accumulated snow plays an important rôle in producing the diurnal variations of temperature in the lower part of the atmosphere. It is, therefore, of some interest to determine the amount of the daily variations of heat content in snow on the ground. The following discussion is based upon the observations of temperature at different depths under the surface of the snow taken at the Kamikawa Meteorological Observatory, in Hokkaido.[1]

The observations were made every hour during eight days from the 16th to the 23d of February, 1907, in the compound of the observatory. The temperature was observed by long-stem mercurial thermometers inserted vertically to the specified depths, and projecting a few centimeters above the surface. The following table contains the results of the observations:

TABLE I.—*Mean temperature (centigrade) for the eight days from February 16 to 23, 1907, at various depths under surface of snow.*

Hour.	Depth in centimeters.				
	0	5	10	20	30
	°	°	°	°	°
1 a.m	−20.91	−17.06	−12.46	−7.92	−5.91
2 a.m	−21.65	−17.80	−12.96	−8.11	−5.97
3 a.m	−22.40	−18.37	−13.47	−8.32	−6.06
4 a.m	−22.65	−18.80	−13.92	−8.51	−6.09
5 a.m	−22.64	−19.07	−14.36	−8.75	−6.12
6 a.m	−22.40	−19.14	−14.71	−8.95	−6.24
7 a.m	−21.67	−18.90	−14.86	−9.10	−6.27
8 a.m	−18.84	−17.42	−14.76	−9.24	−6.31
9 a.m	−13.65	−14.29	−14.09	−9.27	−6.37
10 a.m	−9.81	−10.77	−12.91	−9.34	−6.41
11 a.m	−6.09	−8.12	−11.30	−9.26	−6.47
12 noon	−4.45	−7.06	−9.97	−9.14	−6.49
1 p.m	−3.77	−5.70	−8.76	−8.95	−6.50
2 p.m	−3.82	−5.22	−7.77	−8.62	−6.51
3 p.m	−6.19	−5.77	−7.34	−8.32	−6.51
4 p.m	−8.64	−7.60	−7.37	−8.07	−6.51
5 p.m	−12.56	−9.81	−7.64	−7.92	−6.49
6 p.m	−14.91	−11.40	−8.55	−7.72	−6.44
7 p.m	−15.66	−12.64	−9.25	−7.66	−6.36
8 p.m	−16.40	−13.52	−9.96	−7.61	−6.31
9 p.m	−17.49	−14.22	−10.55	−7.64	−6.21
10 p.m	−17.57	−14.66	−11.09	−7.75	−6.21
11 p.m	−17.79	−15.02	−11.51	−7.89	−6.21
12 midnight	−18.45	−15.49	−11.84	−8.04	−6.19
Mean	−15.02	−13.24	−11.31	−8.42	−6.30

Mr. J. Yamada of the observatory measured the specific density of snow at different depths, and obtained the following results as the mean of the three measurements:

	Depth in centimeters.					
	5	15	25	35	45	55
Density	0.159	0.240	0.267	0.306	0.361	0.380

According to von Bezold[2] the variation of the heat content of the soil per unit area is $\int_0^H C(\theta_2 - \theta_1)\, dh$, where H is the depth of invariable temperature, θ_1 and θ_2 are the temperatures at the depth of h corresponding to the times t_1 and t_2, and C is the heat capacity per unit volume.

[1] From the latest Annual Report, Central Meteorological Observatory of Japan, this observatory is located in latitude 43° 47′ N., longitude 142° 22′ E.; with altitude of barometer above sea level, 113.3 meters.—EDITOR.

[2] Von Bezold: Der Wärmeaustausch an der Erdoberfläche und in der Atmosphäre. 1892. Gesam. Abh. S. 344.

In making the integration an accurate knowledge of the density and specific heat of snow in the different layers is indispensable. By simple interpolations I have calculated the mean density of snow for the various strata, and obtained the heat capacity per unit volume by multiplying the mean density by 0.508, the specific heat of ice. The following table contains the results of my computations:

	Depth in centimeters.			
	0–5	5–10	10–20	20–30
Mean density	0.139	0.179	0.227	0.271
Heat capacity, gram-cal. per cm³	0.0706	0.0909	0.1153	0.1376

Using the above values of heat capacity the integral has been evaluated. The following table contains the result of the summations:

TABLE II.—*Variation in gram-calories of heat content in snow on the ground.*

Time interval.	Depth in centimeters.				
	0–5	5–10	10–20	20–30	Total.
Midnight to 1 a.m	−0.71	−0.90	−0.29	+0.28	−1.71
1 to 2 a.m	−0.26	−0.56	−0.39	−0.17	−1.38
2 to 3 a.m	−0.24	−0.49	−0.41	−0.21	−1.35
3 to 4 a.m	−0.12	−0.40	−0.36	−0.15	−1.03
4 to 5 a.m	−0.05	−0.32	−0.39	−0.18	−0.94
5 to 6 a.m	+0.03	−0.19	−0.31	−0.22	−0.69
6 to 7 a.m	+0.17	+0.04	−0.17	−0.12	−0.08
7 to 8 a.m	+0.76	+0.12	−0.02	−0.12	+0.74
8 to 9 a.m	+1.47	+1.77	+0.36	−0.05	+3.51
9 to 10 a.m	+1.31	+2.14	+0.63	−0.07	+4.01
10 to 11 a.m	+1.13	+1.94	+0.97	+0.01	+4.05
11 a.m. to noon	+0.49	+1.08	+0.83	+0.07	+2.46
Noon to 1 p.m	+0.36	+1.16	+0.81	+0.12	+2.45
1 to 2 p.m	+0.06	+0.66	+0.76	+0.22	+1.70
2 to 3 p.m	−0.52	−0.05	+0.41	+0.21	+0.05
3 to 4 p.m	−0.76	−0.85	+0.13	+0.17	−1.31
4 to 5 p.m	−1.08	−1.13	−0.07	+0.11	−2.17
5 to 6 p.m	−0.70	−1.17	−0.40	+0.17	−2.07
6 to 7 p.m	−0.35	−0.88	−0.37	+0.10	−1.50
7 to 8 p.m	−0.29	−0.72	−0.38	+0.07	−1.32
8 to 9 p.m	−0.32	−0.58	−0.36	+0.04	−1.22
9 to 10 p.m	−0.09	−0.45	−0.37	−0.07	−0.98
10 to 11 p.m	−0.10	−0.35	−0.32	−0.10	−0.87
11 p.m. to midnight	−0.20	−0.36	−0.28	−0.08	−0.92

In the above calculation the summation does not extend to the depth of the invariable stratum. The results given above may therefore be considered as the variations of the heat contained in the stratum above the plane 30 centimeters deep. But as the variation of the temperature at the bottom of the stratum is only 0.6°, the amount of heat which flows in or out across the plane amounts only to a small percentage of the total exchange, and in a rough approximation may be left out of account.

The total daily heat exchange in the snow on the ground is 18.97, or, in round numbers, 19 gram-calories per square centimeter. For comparison we give below the amounts of the diurnal heat exchange in various kinds of soil calculated by Doctor Schubert:[3]

Kind of soil.	(a)	(b)	(c)
Moor soil, with growing conifers	15	......	......
Sand soil, with growing conifers	21	......	24
Moor meadow	43	33	......
Sand soil	80	65	62
Granite rocks	......	134	......

The observations were taken (a) near Lake Lojo, in S. Finland, in August and September, 1892; (b) at the same place in August, September, and October, 1896; (c) at Eberswalde, in July, 1879.

From the above table it may be seen that the heat exchange in snow on the ground is rather large, and is quite comparable with that in soil covered with vegetation.

[3] J. Schubert: Der Wärmeaustausch im festem Erdboden, in Gewässern und in der Atmosphäre. Phys. Zeit. IIIte Band. S. 118.

When clouds cover the sky the greater part of the solar rays can not reach the earth's surface, and the nocturnal radiation of heat from the earth is also hindered. The effect of clouds is, therefore, to diminish the amount of the heat exchange in the upper layer of the earth's crust. In order to see what difference occurs in the heat exchange in the snow layers under consideration on clear and cloudy days I have computed the amounts of exchange in two selected days. As the clear day I have selected February 17, and as the cloudy day, February 23. The mean amount of cloud is 0.8 on the former day, and 9.7 on the latter day. On both days the diurnal temperature wave penetrated below the depth of 30 centimeters. The range of the temperature at this depth was 1.7° on the clear day, and 1.2° on the cloudy day. Hence, in calculating the variations of heat content the quantity of heat which flowed across the plane at 30 centimeters below the surface of the ground must be taken into account. But I have abstained from making such corrections in my computations, since the correction is certainly a small quantity, at most about 5 per cent of the total amount, and in such a discussion as the present one a knowledge of only the order of the required value is sufficient for my purpose. Strictly speaking, therefore, the result obtained below is to be regarded as the diurnal heat exchange taking place in the uppermost 30 centimeters of a deep layer of snow.

Table III contains the amount of the heat exchange on the clear day, and Table IV that on the cloudy day.

Table III.—*Heat exchange (gram-calories) in snow on clear day.*

Time interval.	Depth in centimeters.				
	0-5	5-10	10-20	20-30	Total.
Midnight to 1 a. m	−0.30	−0.64	−0.63	−0.28	−1.85
1 to 2 a. m	−0.35	−0.77	−0.58	−0.41	−2.11
2 to 3 a. m	−0.10	−0.50	−0.52	−0.28	−1.40
3 to 4 a. m	−0.21	−0.50	−0.58	−0.28	−1.57
4 to 5 a. m	−0.17	−0.55	−0.52	−0.34	−1.58
5 to 6 a. m	−0.21	−0.50	−0.46	−0.34	−1.51
6 to 7 a. m	−0.05	−0.27	−0.29	−0.21	−0.82
7 to 8 a. m	+1.09	+0.86	−0.23	−0.28	+1.44
8 to 9 a. m	+1.66	+1.91	+0.40	0.00	+3.97
9 to 10 a. m	+1.67	+2.73	+0.63	−0.28	+4.75
10 to 11 a. m	+1.78	+2.64	+1.15	−0.14	+5.43
11 a. m. to noon	+0.60	+1.00	+0.69	0.00	+2.29
Noon to 1 p. m	+0.47	+1.64	+1.09	+0.14	+3.34
1 to 2 p. m	+0.37	+1.05	+0.86	0.00	+2.28
2 to 3 p. m	−0.51	+0.41	+0.69	+0.21	+0.80
3 to 4 p. m	−0.46	−0.41	+0.40	+0.21	−0.26
4 to 5 p. m	−1.16	−1.14	−0.58	+0.14	−2.74
5 to 6 p. m	−0.70	−1.14	−0.23	+0.21	−1.86
6 to 7 p. m	−0.95	−1.23	−0.35	+0.07	−2.46
7 to 8 p. m	−1.09	−1.64	−0.46	+0.14	−3.05
8 to 9 p. m	−0.54	−1.18	−0.58	+0.14	−2.16
9 to 10 p. m	−0.32	−1.09	−0.75	−0.14	−2.30
10 to 11 p. m	−0.28	−0.59	−0.63	−0.28	−1.78
11 p. m. to midnight	−0.46	−0.82	−0.52	0.00	−1.80

Table IV.—*Heat exchange (gram-calories) in snow on cloudy day.*

Midnight to 1 a. m	−0.12	−0.45	−0.35	+0.14	−0.78
1 to 2 a. m	−0.02	−0.05	0.00	+0.07	0.00
2 to 3 a. m	+0.14	+0.09	−0.06	0.00	+0.17
3 to 4 a. m	+0.14	+0.14	0.00	0.00	+0.28
4 to 5 a. m	+0.05	+0.27	+0.17	+0.07	+0.56
5 to 6 a. m	0.00	−0.09	0.00	+0.14	+0.05
6 to 7 a. m	+0.10	+0.18	+0.17	+0.07	+0.52
7 to 8 a. m	+0.30	+0.36	+0.12	+0.21	+0.99
8 to 9 a. m	+0.46	+0.77	+0.29	0.00	+1.52
9 to 10 a. m	+0.65	+1.00	+0.46	+0.14	+2.25
10 to 11 a. m	+0.40	+0.91	+0.63	+0.21	+2.15
11 a. m. to noon	+0.16	+0.68	+0.46	0.00	+1.30
Noon to 1 p. m	+0.26	+0.50	+0.35	+0.14	+1.25
1 to 2 p. m	−0.28	0.00	+0.40	+0.34	+0.46
2 to 3 p. m	−0.63	−0.59	+0.06	+0.14	−1.02
3 to 4 p. m	−0.60	−0.86	−0.17	+0.07	−1.56
4 to 5 p. m	−0.62	−1.05	−0.36	+0.07	−1.96
5 to 6 p. m	−0.26	−0.45	−0.17	+0.14	−0.74
6 to 7 p. m	−0.16	−0.55	−0.29	+0.07	−0.93
7 to 8 p. m	−0.19	−0.36	−0.23	+0.07	−0.71
8 to 9 p. m	−0.10	−0.41	−0.29	−0.07	−0.87
9 to 10 p. m	−0.21	−0.36	−0.35	−0.14	−1.06
10 to 11 p. m	−0.23	−0.36	−0.12	0.00	−0.71
11 p. m. to midnight	−0.46	−0.64	−0.40	−0.14	−1.64

The total amount of the heat exchange is 24.3 gram-calories on the clear day, and 11.5 gram-calories on the cloudy day. The former is double the latter.

A BIOGRAPHICAL SKETCH OF PROF. DIRO KITAO.

By Dr. S. Tetsu Tamura, Professor of Meteorology and Ocean Physics, Naval Staff College.

[Extract from a memoir, printed in the Journal of the Meteorological Society of Japan, September, 1907.]

* * * Whatever the definition of human greatness may be, it can not be denied that all great men of science have made great and wonderful discoveries, and have inspired their pupils and followers to a nobler ambition, as contributors to the sum of human knowledge. Here in Japan we find an excellent example of such a man in Professor Doctor Kitao, the profound mathematician and original thinker, who has just past away from us (on September 7, 1907), but whose masterful work has left a lasting impression on the progress of theoretical meteorology and mathematical physics.

Prof. Diro Kitao was born in Matsue in the province of Izumo, on the fourth of July of the memorable year 1853 when Commodore Perry first visited Uraga. His father, who was a physician, was called Kwanyu Matsumura, and the early name of Professor Kitao was Rokujiro Matsumura. Young Rokujiro, or Diro, as he was called later, early developed a bent for serious study, and at such a youthful age as ten his rare gifts marked him out as a genius of great promise. It is said that, when yet so young, he already became a master of Chinese classics and history, and wrote several beautiful poems. The attention of Zenichiro Kitao, then a famous scholar of the Dutch language, was attracted by the precosity of the young boy, and finally the elder scholar adopted him and sent him to the schools in Tokyo and Osaka. After some preliminary training at both these places, Diro Kitao was, in 1870, sent by the government to Germany for study. He went thru the gymnasium at Berlin in 1873 and then entered the University of Berlin to study mathematical physics under Helmholtz. Later he was identified with Göttingen University, where in 1879 he wrote a remarkable inaugural dissertation, "Farbenlehre", and took the degree of doctor of philosophy with honors. Doctor Kitao continued his study in Germany for four more years, and it was in one of those years that he invented the Leukoskop and that he met the present Frau Louise Kitao and was married to her. After an absence of fourteen years he returned to his native land with his German wife. During his long stay in Europe Doctor Kitao experienced a great many pecuniary difficulties and even adversities; for tho for the first one or two years he was supported by the Japanese Government, later he had, owing to a change of our governmental system, to support himself by teaching mathematics to lower students or by writing for German magazines and newspapers. It is said that an American Consul to Germany, Mr. Mayer, was greatly interested in Doctor Kitao and assisted him in many useful ways. How hard it is for one to be in such circumstances in a strange country can scarcely be realized except by experience.

The result of his hard study and perseverance was made apparent when, on his return to Japan in 1884, Doctor Kitao was appointed lecturer and soon after promoted to the professorship of physics, in the Imperial University of Tokyo. It was still more apparent when, in 1886, he was appointed professor of physics in the Tokyo Agricultural School and, in 1888, professor of meteorology in the Naval Staff College, while retaining his older position in the Imperial University. In 1890 the Tokyo Agricultural School was made a part of the Imperial University as the Agricultural College, and Doctor Kitao became professor of forest physics and meteorology in the college. This last position he held till recently. In 1891 he received the honorary degree of doctor of science from the university.

The following is the record of his published papers:

1. Zur Farbenlehre.
   (Eine Inaugural-dissertation. Berlin, 1879).

2. Leukoskop, seine Anwendung und seine Theorie.
(Abhandlungen des Tôkyô Daigaku. Universität zu Tôkyô). No. 12, p. 1-102. 1885.
3. Beiträge zur Theorie der Bewegung der Erdatmosphäre und der Wirbelstürme. The Journal of the College of Science, Imperial University, Tokyo.
Erste Abhandlung. Vol. I, Part II, 1887, p. 113-209.
Zweite Abhandlung. Vol. II, Part V, 1889, p. 229-412.
Dritte Abhandlung. Vol. VII, Part V, 1895, p. 293-402.
4. Ueber die Darstellung der Analytischen Gleichungen für Nicht Homogene Curven und Flächen.
Tôkyô Sûgaku-Buturigaku kwai Kizi. Maki no. V, Dai 3, 1894, p. 136-166.
5. Ueber die Integration der durch die Fourierschen Doppelintegrale darstellbaren Discontinuirlichen Functionen. Ditto, p. 167-174. 1894.
6. Eine Methode, Mittelst zweier rechtwinkeligen lineale Cubikwurzel zu finden. Ditto, p. 175-176. 1894.
7. Ueber die Transformation des Ausdrucks $\Delta\phi$ aus linien, welche die Oberflächen ϕ=const. senkrecht durchsetzen. Ditto, p. 177-180. 1894.
8. Ueber das Gesetz der Reibung. Ditto, p. 181-189. 1894.
9. Ueber die electrischen Messungen. Ditto, 190-214. 1894.
10. Ueber die Wasserbewegung in Böden. Bulletin, Vol. III, No. 1, p. 1-113. College of Agriculture, Imperial University. 1897.
11. Ueber Schwinden und Quellen der Hölzer. Ditto, Vol. III, No. 4, p. 299-270. 1898.
12. In wie ferne kann man das Holz als ein isotroper Körper betrachten? Ditto, Vol. V, No. 1, p. 1-39. 1902.

The most important work of Professor Kitao is, no doubt, his "Beiträge zur Theorie der Erdatmosphäre und der Wirbelstürme", comparable with the elegant analysis of Oberbeck and Helmholtz, in fact reminding us remarkably of the work of Kirchhoff. This elaborate memoir, which covers some four hundred pages, was published in three volumes, Volume I in 1887, Volume II in 1889, and Volume III in 1895, in the Journal of the College of Science of the Tokyo Imperial University. On account of its great length and of its highly mathematical nature, it is impossible to reproduce here all its important results; but it may be worth while to give the title of each part. The first volume (§ I-VII) contains the introduction and the discussions of hydrodynamic equations with consideration of the earth's rotation; the general differential equations for the motion of the atmosphere; the general relations between isodynamic lines, wind-directions and vortex-axes; space integration; the equations of atmospheric motions under special assumptions; vorticular motions of the atmosphere; circular cyclones and anticyclones. The second volume (§ VIII-XI) treats of a vortex field of rectilinear isobars; the formation of complex vortices in the atmosphere; special motion in a vortex field; the change of wind-direction, strength, and pressure for a given external point in the case of a double vortex formation. The third volume (§ XII-XIV) treats of the condition for a stationary vortex when two vortices exist; vertical atmospheric circulation; variable vortex formation in the atmosphere. One great characteristic of all the work of Professor Kitao was the reduction of the number of hypotheses to the fewest possible. From this point of view it seems to be the surest guarantee of the permanency of his work.

Why is it that the advancement of modern meteorology is so slow? Is it because of the lack of complete meteorological data, notably in the upper regions of the atmosphere, or because of the complexity of atmospheric phenomena? Will natural difficulties never yield to mathematical analysis until new methods of analysis shall have been developed? Whichever the case may be, meteorology needs for its future advancement the highest mathematical ability, like that of Professor Kitao. During the last quarter of the nineteenth century a vast mass of meteorological observations was piled up, and this accumulation is going on without end and at great expense in every civilized country. A man of mediocre ability can observe and collect facts, but it takes the exceptional man of great mathematical and logical power to draw legitimate theories or conclusions from observations, or to work out the best results from them. Observers and practical meteorologists express the results of their observations by graphic methods; but such methods are entirely destitute of generality, so that if we take analytical theory from the present meteorology we shall leave little but a heap of unrelated facts. The remarkable work of Professor Kitao, however, tells us that mathematical analysis discovers the hidden chain which unites facts so widely distant from each other that ordinary reasoning could not even suspect their connection. True, such scientific achievements are not, perhaps, of the type which most easily commands general attention. They have not yet been utilized in weather-forecasting or in storm-warning. Moreover, the papers written in difficult mathematical language can not be read easily. These may be the very reasons why Doctor Kitao's papers have been read by only a small group of scientists. But such investigators are greatly needed in the future advancement of modern meteorology. By his untimely death the world of meteorology has sustained one of its greatest losses.

Here, however, I must cut short this inadequate account of what the scholar did, that I may say a word or two of what the man was. The extraordinary powers of mind of Professor Kitao were illustrated by the fact that while he accomplished in the difficult fields of mathematics, physics, and meteorology enough to secure his lasting fame, he was able to turn his attention to an entirely different field, the domain of literature and arts. In the first place, Doctor Kitao was an excellent German writer. The fact may clearly be recognized in all his writings and especially in his profoundly interesting novel, "Waldsnymphe", which is left unpublished. This splendidly written German novel consists of fifteen volumes of about one thousand octavo pages each, illustrated with one hundred beautiful pen pictures of his own. Professor Kitao was also a good musician, and especially a skilful pianist; he was a very happy man when playing on the piano with Frau Kitao in the evening. Thus it may be seen that Doctor Kitao was a man of many attainments. He was at once a great mathematician, physicist, and meteorologist, while he was also an excellent writer, painter, and musician. Altho a man of the quietest and simplest manner and of the highest character, he often changed into an eloquent speaker, and no one could meet him without feeling the charm of his personality, when his interest was once aroused in any subject. Professor Kitao was always kind and cordial to his students; moreover his great originality and extraordinary powers of intuition made his lectures most inspiring to advanced students.

Unfortunately I was so young before I went abroad that I had scant opportunity to be personally acquainted with the great scholar himself, and when I returned to Japan, after an absence of nine years, Professor Kitao was seriously ill and had already given up his active service to science. But he has been an ideal teacher, a source of inspiration to me, during the last fifteen years. When I was yet a pupil in a middle school, I learned for the first time the name of Doctor Kitao as a great mathematician. While a student at Aoyama, I often saw a large and distinguished-looking man pass by our school; and when I was told that he was Doctor Kitao returning home from his college, one can hardly imagine how happy I, a poor boy but a student of mathematical turn, was! It was, indeed, my daily enjoyment, tho childish, to stand by my window and watch the great mathematician walk or ride on the avenue along our campus. I had also a good opportunity to read the splendid lectures on higher mathematics delivered by Professor Kitao thru the courtesy of a friend who was one of his students at the College of Agriculture. My greater admiration of him, however, was excited far away in America and Europe. When I was studying mathematical physics and later meteorology under Gibbs, Woodward, and Abbe, and when I met many eminent scientists, the name and work of Doctor Kitao were always highly praised, and I felt as proud of him as if my own master was lauded to the sky. It was

especially his American friend, Prof. Cleveland Abbe, who aroused my interest in meteorology and called my attention to his great meteorological work. Just a year ago I returned to Japan with great enthusiasm and sweet anticipation of seeing our eminent mathematician and meteorologist and of studying under his personal guidance; but alas! I found him intellectually dead. It is, however, a great privilege and honor to me that I now hold the chair of meteorology at the Naval Staff College which Professor Kitao once occupied and that the task of writing his memoir has fallen to my hand.

It is certainly a great misfortune that both his greatness and his work, like those of my former master, Professor J. Willard Gibbs, were not fully appreciated in the world, and were really very little known to laymen as well as to scientists in Japan. * * *

H. C. RUSSELL.[1]

The announcement of the death of Mr. H. C. Russell, who for nearly forty years was among the foremost representatives of science in the colony of New South Wales, has been received with great regret by many men of science. Since 1870 he held the post of government astronomer and director of the Sydney Observatory, in succession to Mr. G. R. Smalley, and in that capacity rendered most important services to the colony. His first duty on appointment was to organize the resources of the colony for the observation of the transit of Venus. With small funds, little skilled assistance, and short time for preparation he nevertheless succeeded in equipping several stations in a highly efficient manner, reflecting great credit upon the readiness of the colonists and the exertions of the observatory staff.

Thenceforward the observatory pursued a course marked by continually increasing usefulness, culminating in the acceptance of a share in the international photographic chart of the heavens. * * *

But most of all the colony is indebted to him for his organization of the meteorological service. He had charge of a district of the climate of which little was known, and as the colony extended and the population occupied areas of unexplored country, he had to widen the range of his inquiry in order to supply the necessary information to intending settlers. The long series of observations that he published on climate factors, especially those having reference to rain, evaporation, and state of the rivers, attest to his industry, his powers of organization, and his recognition of the requirements of a young and rising colony. He put it on record that when he assumed office there were but five rain-gauges in the colony. On his retirement there were something like two thousand. His discussion of the results has scarcely been as happy as his collection. He seems to have relied upon statistical methods rather than on physical facts, and in this way was led to suggest a theory which would make the amount of precipitation depend upon the moon's nodes. These cycles are shown very distinctly over the few years that he was able to bring under discussion, but his explanation has not been generally accepted. This is a small matter in comparison with the value of the information which he was able to furnish, and which has contributed in no small degree to the prosperity of the colony. This collection of observations will be of the greatest service in subsequent inquiries.

Mr. Russell has left a character for industry and closeness of application that can not but prove stimulating to future astronomers in the southern hemisphere. He was much esteemed by many friends in this country, who regretted his retirement from the observatory; and besides being a Fellow of the Royal Society, to which he was elected in 1886, he was a member of many learned bodies, and was well known as a contributor of frequent and welcome papers.

[1] Part of an obituary notice signed "W. E. P.", printed in Nature (of London), issue of March 7, 1907. Mr. Russell was a member of the International Meteorological Committee. His death occurred at Sydney, Australia, February 22, 1907.—EDITOR.

AN IMPORTANT METHOD IN AERIAL RESEARCH.

As many individuals in this country wish to do something in connection with the recent development of the study of the free air, the Editor takes pleasure in commending to their attention the following translation of an article by Doctor de Quervain, the enthusiastic assistant to Professor Hergesell as secretary of the International Union for Aerial Research. De Quervain's success in Europe in keeping sight of a small balloon (with the help of a special telescope) demonstrates that still better work can be done in the clear air of our prairies and mountain plateaus, where especially we need to know more about the upper currents, and where de Quervain's methods are the least expensive and troublesome of all as yet devised.

In this connection it is worth noting that the need of a better knowledge of the upper currents, the altitudes of clouds, etc., led the Editor to urge the use of pilot balloons in 1871, but an adverse report hindered the work. In 1872 he fitted out the *Florence* arctic expedition with the necessary instructions, including the method for determination of the vertical velocity at each ascension, but it afterwards appeared that the hydrogen gas apparatus was left on shore at New London. In 1889 he carried a large supply of balloons on the cruise of the *Pensacola* round the Atlantic, but the carboy of sulfuric acid frequently made trouble on the deck of the vessel and was soon thrown overboard, so that the work had to stop. (An order to send the carboy "below" was interpreted by the crew to mean "Davy Jones's locker"!)

There are many difficulties in store for us, but we must do the best to overcome them, and make every possible effort to use balloons and kites in the study of the atmosphere. A convenient apparatus for filling small balloons with hydrogen can be bought of the dealers in New York, N. Y., and many chemical laboratories have something equivalent. We hope to hear of these being used for meteorological work.—*C. A.*

A PROPOSAL THAT PILOT BALLOONS BE MORE GENERALLY USED IN MAKING METEOROLOGICAL OBSERVATIONS.

By Dr. A. de QUERVAIN. Translated from Das Wetter, May, 1906, by Dr. C. Abbe, jr.

In investigating the free air it is just as important to have a knowledge of the direction and velocity of the air currents at different levels as it is to know the distribution of temperature. In many cases accurate cloud observations yield us fairly accurate information concerning the directions of these currents. Such observations are yet more valuable if the observatory is also in a position to measure the altitudes of the clouds.

On fine clear days the atmospheric currents even at great altitudes may be studied most advantageously by determining trigonometrically the course of a sounding balloon with the aid of some appropriate instrument. Such a series of observations presented so many practical difficulties, especially in the case of Assmann's rubber baloons, which are now generally used, that until recently no one had undertaken them. Since the accurate study of atmospheric currents has long seemed to me to be of the greatest importance, I have, during the past five years, made numerous practical attempts to work out a method for doing this. Finally, with the support of the firm of J. and A. Bosch, of Strassburg, I succeeded in constructing a special theodolite[1] by the aid of which I found it possible on clear days to determine the path of a sounding balloon with certainty and convenience up to altitudes of over 16,000 meters, and to horizontal distances of over 60 kilo-

[1] See the detailed description in Zeits. Inst'kunde, 1905, p. 135; and Met. Zeit., 1906, p. 149.

meters. Thus it was that in my first trial of the new instrument, while following in the usual way a sounding balloon of the Strassburg Meteorological Institute, I was able for the first time to show that there is a change in the direction of the air currents at the level of the well-known inversion layer at 12,000 meters.[2] I had already, with an experimental model at an earlier date, succeeded in showing that a balloon followed a peculiar looped path at this same level,[3] a conclusion that has since received interesting confirmation in the observations made by Dr. A. Wegener, with one of my instruments, at the Lindenberg Aeronautical Observatory.[4]

Since this new method of observing has yielded the best results from the very beginning, both in these and other cases, there is no doubt but that in the future this determination of the balloon's path will everywhere form a part of the regular program during the ascension of sounding balloons. I would here make special mention of the plan proposed by Professor Assmann, that there be a month of daily ascents of sounding balloons during the Milan Exposition, and that, as far as possible, the courses of all the balloons be determined by this instrument. The most interesting revelations concerning the atmospheric circulation above that region [northern Italy] are to be expected from the carrying out of such a plan.

It is evident that such numerous flights of sounding balloons can be made only where unusual means are at hand. It is possible, however, to secure an important portion of the results, viz, a knowledge of the motions of the atmosphere, at a much smaller cost simply by using pilot balloons. As soon as my theodolite was completed I began trials to determine the distance and the height to which the ordinary child's toy balloon of different sizes could be followed. The favorable results then obtained led to further trials[5] with somewhat larger balloons, at the Meteorological Institute in Strassburg, and in Zürich. These experiments showed that, under favorable circumstances, balloons smaller than the usual sounding balloon and costing only 4 or 5 marks, can be followed to altitudes of more than 8000 meters, while in clear weather it is always possible to follow them to about 5000 meters. If slightly larger balloons were used no doubt the atmospheric currents could be studied up to altitudes of about 10,000 meters. I believe that there is a field here for very valuable observations at those institutions which have but modest means at their command. By observations of such pilot balloons the movements of the atmosphere may be accurately determined to great heights on many and indeed on most days of the year, at relatively small cost and labor. * * * The accuracy of these determinations depends, first of all, upon an accurate knowledge of the balloon's ascensional velocity, and this may be reliably determined to within 5 per cent in individual cases. The degree of accuracy of the resulting horizontal velocity will be in a similar ratio. One can see that the attainable accuracy is quite sufficient for the purpose and wholly so for present needs. An accurate comparison of the ascents of sounding balloons at Strassburg shows that they maintain a very uniform vertical velocity, and Professor Hergesell has shown that such is also the theoretical expectation.

It is not at all necessary that the heavens be perfectly clear during the ascension of a pilot balloon. If the clouds are not too low down one may rest satisfied with determining the air-currents up to the cloud level. The altitude of the clouds may be pretty accurately deduced from the time at which the balloon disappears in them; and this, together with the determination of the relative velocity of the clouds, gives accurately the actual velocity of the cloud layer. In the numerous cases where the sky is covered with alto-cumulus or alto-stratus the balloon will have already attained a considerable height before it reaches the cloud. Even on days when the sky is almost completely covered with low-lying clouds, it is very often possible to seize a half hour when at least the lower layers break up for awhile and permit a successful pilot-balloon flight to be made.

In order to gain even an approximate idea as to how many days in the year might be appropriate for such experiments I have compiled for Zurich, Strassburg, Berlin and Milan, the frequencies for two years of such days as showed five-tenths or less cloudiness at at least one of the three observation hours. For Milan I took from the decade-summaries the days having "cielo sereno" and "mista senza precipitazione", which probably gave comparable but too small values. It may be assumed that on such days there may always be found a still more favorable moment for the attempt than at these special hours of observation. The numbers of such favorable days were:

Milan	214
Zurich	209
Strassburg	218
Berlin	213

These numbers should be considered rather as minimum values. On the other hand many difficulties may occur which are independent of the weather. Hence, in calculating the cost of a station which is to take advantage of all favorable conditions, one may count on about 200 observations per year.

Suppose, further, that balloons be used which cost five marks apiece and have an ascensional force of 150 to 250 grams, their ascensional velocity being 4 to 5 meters per second, these permit of being readily followed to altitudes of 4,000 or 5,000 meters and higher. On days when the clouds hang lower, smaller balloons, costing four marks, would be used; and in perfectly clear weather somewhat larger ones, which can possibly be followed to altitudes of 10,000 meters. We shall not here consider those cases where specially large balloons would be risked in order to send them above the the level of the upper inversion stratum and the cirrus clouds. The annual cost, under ordinary conditions, would thus amount to about a thousand marks ($250) for the pilot balloons, and 50 to 100 marks, according to circumstances, for producing the hydrogen gas. Further, each ascent would occupy two persons for about one hour, and in addition one or two hours would be required for the (immediate) working up and plotting of the balloon's path. In regard to this latter point it may be remarked that frequent practise in such observations would lead to many simplifications, e. g., the proper foresight in preparation and in the making of the observations. Simple trials would enable one to determine, once for all, what ascensional force produced a given ascending velocity, e. g., 5 meters per second. It would be an easy matter to devise some filling device which would almost automatically close the balloon as soon as it had acquired the desired lifting power, thereby avoiding the necessity of repeatedly testing and trying before getting the right amount. Again, in observing the flight of the balloon one would have to form the habit of making readings, not at irregular times, but rather at every whole minute, for example. In this way certain even levels for the calculations would be fixt in advance, and by using appropriate summary tabulations of the proper goniometric functions (to three decimal places and to tenths of a degree) the calculations could be performed systematically and rapidly, sometimes even during the flight itself. The proper course will be to plot the locations of the nadir of the balloon graphically in rectangular coordinates, and take the course and velocity from this horizontal projection. Perhaps it would be still simpler to avoid all calculations by adopting a procedure similar to that followed at Blue Hill during the year of international cloud observations. In this method one

[2] See Beiträge zur Physik der freien Atmosphäre, Bd. 1, p. 143.
[3] Ibid., p. 47. [4] Ibid., bd. 2, heft 1.
[5] It should be recalled that von Sigsfeld and Professor Kremser both put this idea into execution thirteen years ago, using paper balloons.

simply places a very small theodolite provided with an index arm, reading to 1/10 degree, directly over the origin of the coordinates on the drawing paper, and sights upon a divided rule supported vertically. Better still would it be to set the small theodolite at the reading, for any moment, of the large instrument with which the balloon is observed, and then bring the mark on the divided rule corresponding to the altitude at that moment, into the line of sight of the theodolite. The sharp point marking the location of the foot of the rule would then indicate the position of the vertical projection of the balloon or its nadir. There is no doubt that, with a little practise, the path of the balloon could be graphically plotted in a few minutes by this method. However there would be a certain amount of difficulty when the angular altitude became very great, and in general for the first few points of every path traced. Whichever method be selected, the observer will have to accustom himself to carrying out the measurements in a definite routine and an intelligible way. I foresee the time when the watchman of many a meteorological observatory will perform these duties in the same apathetic way in which he now goes about the routine of the periodic observations which today constitute the observational portion of the observatory duties.

At first, to be sure, one will regard the reduction of each new observation as a *novum atque inauditum*, as regards its results. Yet even if such regular observations and measurements are inaugurated at only a single station, the expense and trouble entailed would be richly repaid, especially at localities having fine weather, by the incomparably more accurate knowledge thus gained, as compared with our present knowledge concerning changes in the direction and velocity of the wind with increasing altitude. What splendid support such a series of measurements would afford to works like the admirable investigations into the circulation of the atmosphere by H. Hildebrandsson[6]. How much more excellent support would be furnished if we had simultaneous observations from a number of stations. Many, and perhaps those precisely who have the progress of meteorology most at heart, will be somewhat skeptically inclined toward a proposal for new simultaneous international observations. Ever new demands, and where is the fulfilment of earlier promises?

In reply, it must first of all be emphasized that the present case does not seem to call for any special prearrangement or international preparation beyond an occasional arrangement among those actively interested so that the results may be published as soon as possible. It is superfluous to make any special agreement as to dates for the flight trials, since the observations are to be made on every day that is in any degree favorable for them, and hence they are necessarily as simultaneous as it is possible for them to be.

To those whose past experience induces a certain hesitancy toward these new proposals I would present the following considerations. In the case of the international simultaneous observations in the free air as thus far carried out, with which one mentally connects my present proposition, we are dealing with measurements which demand extraordinary care if the quantities that it is intended to measure are to be truly comparable. This can not be secured thru the improvement of the instruments alone. The sources of error are so numerous and so great that unless each and every point is taken account of in the handling of the instruments and the calculation of the results, the resulting uncertainties will exceed the very differences which it is desired to determine. Unfortunately, it has also been found that the requisite many-sided painstaking qualities and the delicate sense of the physicist are not possest by every one, and cannot be purchased with the instrument from the manufacturer. If then, and chiefly for these reasons, the above-mentioned international arrangements have not yet met with the unqualified success which was once expected of them, and if the more accurate discussion of their results has been so far delayed precisely because they are believed to be not perfectly comparable—still similar doubts should not be transferred to the simpler simultaneous observations which I here propose. To be sure, even these observations demand a certain degree of care, as do all that are to be of any value at all. But the sources of error are much more limited and the possible errors are of much smaller magnitude as compared with the quantities to be measured. The procedure is indeed a right simple one: determine the buoyancy or ascensional force of a balloon, sight the telescope, read a clock and a coarsely divided circle; all these manipulations demand only a fairly delicate physical sense (the light touch and sharp eye of a good observer); and if they are carried out by a man who is at all conscientious in his work can not well fail to be sufficiently well executed. One is therefore justified in assuming that, in general, we shall not have to deal with results which may be accepted "only with great caution".

The measurements under discussion possess the further advantage that the results can be deduced and applied immediately after the experiment, an advantage so much emphasized as attaching also to the otherwise very troublesome kite flights. Without indulging in unfounded hopes I seriously expect to find such pilot-balloon observations of some value in weather forecasting. It is true that the evidence for this is as yet lacking, because I have no materials on which to base the statement. General considerations, however, make it quite clear that precisely at the times of change from fair weather to rain, which are the special difficulties of the forecaster, there must occur changes in the upper circulation whose significance would thereby be learned. To all earnest, experienced forecasters, to all those who do not approach their predictions in the spirit of Kepler when casting horoscopes, but who would endeavor to attain the attainable, I would put this question: "Do you believe that in the presence of that sudden, recent change of weather the accurate knowledge of the wind's direction and velocity at levels of 5000 to 10,000 meters would have aided you in forecasting"? If the answer is "yes", then I would say that in the future this knowledge may be cheaply and readily secured. If the answer be "no", than I would ask: "What attainable data would be of help?"

For the present it is to be urgently recommended to all institutions and private students who are in any wise able to carry them out, that they inaugurate continuous and regular observations of pilot-balloon flights. The results will soon prove to have a purely scientific value and probably will also be of importance in forecasting.

[6] I refer particularly to the second part of his "Rapport sur les observations internationales de nuages", Upsala, 1905.

HERMAN DECLERCQ STEARNS.

By G. A. CLARK, Secretary Leland Stanford Junior University, Palo Alto, Cal.
Dated November 15, 1907.

Herman Declercq Stearns, associate professor of physics in Leland Stanford Junior University, died of tuberculosis on October 21, after an illness of four years. Professor Stearns was born in Joliet, Ill., September 14, 1865. His preparatory education was gained in the public schools of Joliet. After graduating from the high school he became a teacher, and taught for some time in the Joliet High School, later becoming principal of the public school at Lake Forest, Ill. He entered Lake Forest University with the class of 1892, but left in 1891 to enter Stanford University, which opened that year. He took his A. B. degree at Stanford in 1892, and his A. M. degree in 1893. He was made instructor in physics in the university in 1893, assistant professor in 1896 and associate professor in 1900. He was a student in the University of Berlin during the academic year 1897–98, where he gave most of his time to the study of meteorology under von Bezold.

Professor Stearns excelled especially as a teacher of physics. He published but few papers, principally on the phenomena of thunderstorms.[1] His best known piece of experimental work was in the determination of the magnetic susceptibility of water, the results of which were published in the Physical Review of January, 1902.

Professor Stearns was married in 1894 to Miss Florence Curry of Streator, Ill., who survives him.

THE LAGGING OF TEMPERATURE CHANGES AT GREAT HEIGHTS BEHIND THOSE AT THE EARTH'S SURFACE AND TYPES OF PRESSURE CHANGES AT DIFFERENT LEVELS.

By HENRY HELM CLAYTON, meteorologist of the Blue Hill Observatory. Dated Hyde Park, Mass., November 30, 1907.

By permission of Prof. A. Lawrence Rotch, director of the Blue Hill Observatory, I am able to publish, in advance of a more detailed discussion by me in the Annals of the Astronomical Observatory of Harvard College, a few results of interest derived from a study of the records obtained with sounding balloons launched from St. Louis, Mo.

One of the earliest facts disclosed by the records obtained in the free air with kites at Blue Hill was that changes of temperature occur earlier at heights of 500 to 1000 meters than at the earth's surface.[1] It had also previously been disclosed by a study of the observations on Mount Washington that changes of temperature usually occur earlier at the summit than at the base.[2] In a recent number of the MONTHLY WEATHER REVIEW,[3] Prof. C. H. McLeod proposes to predict weather changes from observations on Mount Royal, Montreal, which show the coming of weather changes earlier there than at low stations.

Long before the fact of the earlier coming of temperature changes at heights of 500 to 1000 meters had been established, it was inferred that a change of temperature would occur first in the upper air because the upper currents move so much faster and overflow those below. This assumption has been used for many theoretical explanations of thunderstorms, tornadoes, waterspouts, and even of general storms. However, the recent records obtained at St. Louis with sounding balloons, by the staff of Blue Hill Observatory, show that at all heights except within about 1000 meters of the earth, the temperature changes occur successively later with increasing height above the ground. This fact is best shown by the records for April and May, 1906, because this series of observations is more complete and for a longer interval than any other yet obtained at St. Louis. The balloons were liberated by Mr. S. P. Fergusson near sunset each day, and the highest point, varying between 3 and 15 kilometers, was reached between 7 and 9 o'clock. Records were obtained on every day from April 28 to May 19, with the exception of three days. These records make it possible to follow the changes of temperature from day to day at different heights. The temperatures on different days at successive heights of 5 kilometers are shown in Table 1, and the results are plotted in Fig. 1.

It is apparent from the table and from fig. 1 that maxima and minima in temperature occur very considerably later in the upper air than at the earth's surface. What appear to be similar maxima and minima at different levels are marked by similar numerals, *1*, *2*, *3*, etc., in fig. 1.

By comparing the temperature maxima and minima at the ground, 167 meters above sea level, with the maxima and minima at 10,000 meters, it is seen that the maxima and minima at 10 kilometers occur almost constantly about twenty-four hours later than at the ground. The observations are not in sufficient detail to show whether this retardation is gradual from level to level or occurs in irregular steps; but apparently the change is not gradual. The maximum marked *5* occurs simultaneously at 5000 and at 10,000 meters, but occurs there about a day later than at the ground. On the other hand the maximum marked *8* occurs simultaneously at the ground and at 5000 meters, but occurs a day later at 10,000 meters. However, as observations were taken only once a day it is not possible to follow any gradual shifting occupying only one day. The observations at the height of 15,000 meters were not sufficiently numerous to follow the changes easily, but apparently the irregular ranges of temperature at this height are very much less than at sea level. From May 2 to 10, inclusive, records were obtained at each level from the ground to 10 kilometers, and during part of this time there were records at 15 kilometers also. The means of the changes of temperature from one day to another at different levels are found to be as follows: at the ground, 6.0° C.; at 5 kilometers, 5.2°; at 10 kilometers, 7.1°; and at 15 kilometers, 2.9°. These results indicate that the irregular changes of temperature reach a maximum at 10 kilometers, and suddenly decrease at 15 kilometers. Between these two levels there is found a marked inversion of temperature in both Europe and America; the air at 15 kilometers is warmer than that at 13 to 14 kilometers, and it may be that the changes in temperature in the two strata have little in common.

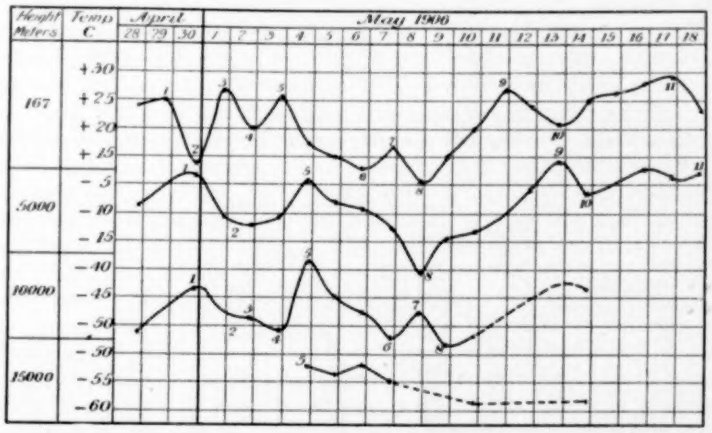

FIG. 1.—The temperatures at successive heights above sea level derived from records obtained with sounding balloons ascending from St. Louis, Mo., April and May, 1906.

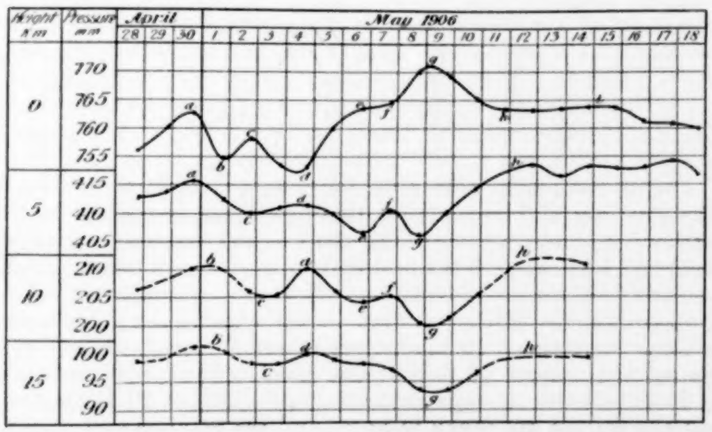

FIG. 2.—The pressures at successive heights above sea level derived from records obtained with sounding balloons ascending from St. Louis, Mo., April and May, 1906.

The mean pressures at different heights from sea level to 15 kilometers are given in Table 2. In obtaining these results

[1] See Monthly Weather Review, October, 1898, vol. 26, p. 452, "The effect of proximity to the sea on thunderstorm periods."

[1] See Blue Hill Meteorological Observatory Bulletin, No. 2, 1898, p. 2; also Annals of the Astronomical Observatory of Harvard College, vol. XLII, part I, 1897, p. 107.

[2] See American Meteorological Journal, vol. IV, p. 268, 1887.

[3] November, 1906, vol. XXXIV, p. 505–510.

the observed pressures at St. Louis were reduced to sea level, and the pressures at 10 kilometers were reduced to 15 kilometers on the days when there were no records at 15 kilometers, using for this purpose the mean observed difference in temperature between the two strata. The pressures at all other heights were derived from the records of the sounding balloons.

TABLE 1.—*Temperatures at different heights above sea level derived from records obtained with sounding balloons sent from St. Louis, Mo., 167 meters above sea level.*

Date.	Hour.	Height.	Temperature.	Date.	Hour.	Height.	Temperature.
1906.	*P. M.*	*Meters.*	°*C.*	1906.	*P. M.*	*Meters.*	°*C.*
April 28	7:33	167	24.4	May 8	7:05	167	10.1
	8:00	5,000	−8.8		7:33	5,000	−20.6
	8:52	10,000	−50.7		8:07	10,000	−47.5
29	7:00	167	24.6	9	6:55	167	15.0
30	6:14	167	14.1		7:24	5,000	−14.6
	6:49	5,000	−3.8		8:04	10,000	−53.2
	7:33	10,000	−42.9		8:34	12,500	−53.7
	8:09	12,000	−55.6	10	6:40	167	20.0
May 1	6:40	167	26.7		7:09	5,000	−13.6
	7:22	5,000	−10.9		7:41	10,000	−51.4
2	7:05	167	20.0		8:15	15,000	−58.1
	7:45	5,000	−11.9	11	7:00	167	27.1
	8:41	10,000	−48.0	12	6:33	167	23.9
3	6:07	167	25.6		7:22	5,000	−5.5
	6:47	5,000	−10.5	13	9:00	167	21.1
	7:50	10,000	−50.8		9:36	4,000	3.4
4	8:46	167	17.2	14	6:33	167	25.3
	9:03	5,000	−4.3		7:04	5,000	−6.9
	....	10,000	−37.8		7:37	10,000	−44.2
	....	13,000	−51.4		8:04	15,000	−58.0
5	6:54	167	15.0	15	6:52	167	26.1
	7:26	5,000	−8.0	16	6:46	167	27.9
	8:02	10,000	−45.0		7:17	5,000	−2.5
	8:58	15,000	−54.2	17	6:26	167	29.0
6	6:50	167	13.4		7:02	5,000	−3.5
	7:23	5,000	−8.4	18	6:19	167	23.2
	7:56	10,000	−47.0		6:50	3,500	5.8
	8:24	15,000	−51.7				
7	7:14	167	16.1		*A. M.*		
	7:47	5,000	−13.2	19	5:36	167	20.0
	8:22	10,000	−53.2		6:18	5,000	−3.2
	9:08	15,000	−55.0				

TABLE 2.—*Pressures at different heights above sea level derived from records obtained with sounding balloons sent from St. Louis, Mo., 167 meters above sea level.*

Date.	Pressure at sea level.	Pressure at 2 kilometers.	Pressure at 5 kilometers.	Pressure at 10 kilometers.	Pressure at 15 kilometers.
1906, 7 p. m.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
April 28	757	599	413	207	99
29	761	....	....	....	....
30	763	602	416	211	101
May 1	754*	599	412	....	....
2	758	598	410	206	98
3	754	598	411	205	98
4	753*	595*	411	210	100
5	760	597	410	206	98
6	763	598	407	204	98
7	764	601	411	205	97
8	770†	601	406*	200*	93*
9	769	604	410	202	93
10	765	604	413	206	97
11	763	....	....	....	....
12	763	605	418	....	....
13	763	605†	417	....	....
14	763	605	418	211	99
15	763	....	....	....	....
16	762	605	418	....	....
17	761	605	419†	....	....
18	760	603	417	....	....

* Minima. † Maxima.

The pressures at different heights are plotted in Fig. 2. The maxima and minima in this figure are indicated by the letters *a*, *b*, *c*, etc. Comparing the maxima and minima at sea level and 5 kilometers the first maximum *a* occurs nearly simultaneously at the two levels, but after that the maxima in one level coincide with the minima in the other. This inversion is more marked at 10 kilometers where the pressure curve is almost the reverse of that at sea level. The pressure curve at 15 kilometers is somewhat similar to that at 10 kilometers, but the ranges are much reduced and the maxima and minima are evidently on the point of disappearing. In fact, in the interval from the 4th to the 8th, which was best covered by observations, the smaller fluctuations found at 5 to 10 kilometers do not occur at 15 kilometers. In the upper-air type of curve there is distinct evidence of lagging in the time of the most marked maxima and minima. The minima *c* and *g* and the maximum *d* evidently occur about twelve hours later at 10 to 15 kilometers than at 5 kilometers.

In order to ascertain at what level in the atmosphere the sea-level type of pressure changed to the upper-air type, the pressure for each day was obtained from the records for the height of 2 kilometers. These pressures are given in the third column of Table 2. The results show that the sea-level minimum of May 1 did not exist at 2 kilometers; but the minimum of May 4 was well defined at that level, altho with diminished range, and disappeared between 2 and 5 kilometers. The well-defined maximum at sea level on May 8 is not shown at 2 kilometers, and is replaced at 5 kilometers by a sharp minimum of pressure. These results indicate that the sea-level type of pressure does not extend to heights much exceeding 2 or 3 kilometers. This conclusion is sustained by the observations of clouds at Blue Hill, which show that the air ceases to rotate around centers of high and low pressure at heights of about 3 kilometers, and that above that height the motion is of an entirely different character, consisting only of deflections to the right and left in a general easterly drift.[4] When the pressures are charted synoptically, there are found at sea level elliptical isobars around which the wind circulates, going spirally inward or outward, according to whether the central pressure is lower or higher than that in surrounding regions. At about 3 kilometers this type changes suddenly to the upper-air type of pressure, in which the isobars are U-shaped or semi-circular, and not circles or ellipses as at the ground. The bottom of the U points southward when the pressure is below the normal, but is inverted (∩) and points northward when the pressure is above normal. In this type the line of minimum pressure is found near the place of minimum temperature, and many hundreds of miles distant from the minimum of pressure at the earth's surface. The line of maximum pressure is found near the place of maximum temperature, and far from the maximum pressure at the earth's surface. To some extent these facts were outlined by Doctor Köppen as long ago as 1888, when he first plotted isobars for the upper air; but it is not uncommon to find in the writings of meteorologists of to-day references to areas of high and low pressure as if they extended to great heights in the atmosphere. In future I think we must ascribe the unstable vertical gradients of temperature, which give rise to thunderstorms and tornadoes, not to the overflow of surface air by potentially cooler air above, but rather to the northward flow of relatively warm air at low levels, beneath currents moving from the west or northwest above, or to the heating of the ground and surface air by the sun.

My conclusion that cold waves are inclined strata of descending air felt first at the earth's surface and successively later at greater heights is given in the MONTHLY WEATHER REVIEW for March, 1907.[5] The reason of the later occurrence of warm waves aloft is no doubt because the areas of low pressure in the upper air are in the rear of areas of low pressure at sea level. The winds in front of these areas of low pressure in the upper air have a component of motion from the south and hence are relatively warm; while the winds immediately below, in the rear of the lows at sea level, have a component of motion from the north, forming the advancing lower front of the cold wave, and are relatively cold.

OUR PRESENT KNOWLEDGE REGARDING THE HEAT OF EVAPORATION OF WATER.

By Prof. ARTHUR WHITMORE SMITH, Ph. D. Dated University of Michigan, Ann Arbor, Mich., November 20, 1907.

Until quite recently our knowledge of the amount of heat required to evaporate water has been derived from the classic

[4] See Annals of the Astronomical Observatory of Harvard College, vol. XXX, 1896.

[5] Vol. XXXV, p. 118-120.

experiments of Regnault, and even to-day, in spite of half a dozen modern researches, his results are quoted and used by scientists generally more often than all the others combined. Most of Regnault's work dealt with high temperatures, and these results are still of undoubted value; but Regnault himself expresses doubt regarding the accuracy of his results at low temperatures. Nevertheless the confidence which is inspired and justified by the accuracy of his work at the higher temperatures is often extended to the entire range, without any examination of the original data. It is the object of this paper to set forth our present knowledge of the subject as shown by the most reliable investigations of recent years.

Dieterici.—Undoubtedly the best determination of the heat of evaporation of water at low temperatures is that of Dieterici.[1] In 1889 he evaporated water within a Bunsen ice calorimeter. The water was placed in a small bulb within the inner tube of the calorimeter, and after thermal equilibrium was fully established all the water was evaporated by means of reduced pressure—the heat required being furnished by the further freezing of the ice mantle. Assuming that one mean calorie will expel 0.01544 gram of mercury—this being the average of the values found by Bunsen, Schuller and Wartha, and Velten—he obtained[2] the value 596.80 mean calories for the heat of evaporation at 0° C. Eliminating this assumption, what he really determined in this investigation was that

$$.01544 \times 596.80 = 9.2146 \text{ grams of mercury}$$

were expelled from the ice calorimeter when one gram of water at 0° C. was evaporated into vapor at the same temperature.

Dieterici has recently calibrated his ice calorimeter in terms of the electrical units. A carefully measured electric current past thru a fine resistance coil within the inner bulb of the calorimeter. As the ice mantle melted, thus reducing its volume, mercury was drawn into the calorimeter, the exact amount being found by careful weighings. In a series of ten experiments[3] the total amount of heat supplied by the current was 3049.28 joules. The corresponding total amount of mercury drawn into the calorimeter was 11.2663 grams. The electrical units are exprest in terms of a Weston element, and probably the above result is exprest in Reichsanstalt joules. Since Reichsanstalt volts are larger than international volts by the factor 1.00081, and this factor enters twice in the formula EIT by which the electrical energy was computed, we have for the amount of heat corresponding to each gram of mercury drawn into the calorimeter

$$3049.28 \times (1.00081)^2 \div 11.2663 = 271.09$$

international joules per gram of mercury.

Combining this result with that of the earlier investigation gives at once for the heat required to evaporate one gram of water at 0° C.

$$9.2146 \times 271.09 = 2498.0 \text{ international joules.}$$

Dieterici has also made a direct calibration of his calorimeter in terms of "mean calories", that is, in terms of one-hundredth of the amount of heat that a gram of water gives out in cooling from 100° C. to 0° C. The water was inclosed in a small quartz tube, both tube and water being heated to about 100° C. and then dropt into the calorimeter. Correction was made for the heat carried by the quartz tube. The mean of 13 experiments gave 0.015491 gram of mercury per mean calorie.[4] This result is larger than other determinations of the same constant, and therefore must carry some doubt until corroborated by further reseaches. Using this value Dieterici finds 4.1925 for the mechanical equivalent of heat, which likewise is larger than the accepted value. Combining this result with his earlier ones gives

$$9.2146 \div 0.015491 = 594.83$$

mean calories per gram of water evaporated. But this result is not as reliable as the preceding one.

A. W. Smith.—Coming next in the order of ascending temperatures is the recent investigation, the full account of which I have given in a previous paper.[5] The method used was to draw a stream of dry air thru the water within a calorimeter, thus evaporating some of it. An unvarying electric current furnished heat in a form susceptible of precise measurement, while the stream of air was continually adjusted to evaporate just enough water to maintain a constant temperature. This air current, after leaving the calorimeter laden with water vapor, bubbled thru two baths of sulfuric acid in which it was reduced to the same degree of dryness that it possest just before it entered the calorimeter. Therefore whatever water it took from the calorimeter was left in the sulfuric acid, the amount being determined by careful weighings on a precision balance. Special pains were observed that no water could escape from the calorimeter in the form of spray or fine drops carried by the air current; and the air current, after leaving the calorimeter, past thru warmer tubes where it could not deposit any of the water it was carrying in the form of vapor.

This method possesses several advantages over others that might have been used. The water is slowly evaporated into air at nearly atmospheric pressure, so the method corresponds more nearly to natural evaporation than when the water boils under reduced pressure. Besides water does not boil easily or steadily at these low temperatures. But the principal advantage is that an experiment can be commenced or ended at any time without disturbing the set-up in the least, and one experiment can follow another with no interval between. When the calorimeter is holding a constant temperature, with the air current bringing away its steady stream of water vapor and the electric current supplying the equivalent amount of heat, an experiment, so-called, can be made at any time that is convenient. An experiment is really only a single determination of the *time rate* of this stream of vapor, and several such determinations can be made in one day. For this purpose the two sulfuric acid tubes are inserted in the outcoming air current for a measured interval of time. When these tubes are removed fresh ones are put in their place, and no vapor escapes unmeasured. Such a series of successive determinations is more valuable than the same number of experiments made at different times, because whatever thermal uncertainties may be left at the end of one run are carried forward to the next. For example, if some part of the calorimeter should be warmer at the close of an experiment than it was at the beginning, thereby holding heat which should have been used for the evaporation of water, and if during the next run, when equilibrium is attained, the extra evaporation makes the collected water too large, then the average of these two results will not only possess the usual weight of a mean, but it will be absolutely correct as regards this particular kind of uncertainty. It is for this reason that the experiments are made consecutive, one beginning where the other left off, until a set of four separate determinations has been made.

The energy supplied by the electric current was computed from the formula EIT. Both the current I and the fall of the potential E were measured in terms of a standard cadmium cell. The particular cell used was compared both before and after the experiments with the best cadmium cell in the laboratory, whose electro-motive force in terms of the Clark cell is very exactly known. Therefore all measurements are really based upon the electro-motive force of the Clark cell as set up according to the regular specifications, which is given as 1.434 international volts at 15° C. They are thus given in terms of a definite and reproducible unit. Should the electromotive force of the Clark cell be found to be less than this

[1] Ann. der Phys., vol. 37, p. 494-508, 1889.
[2] Ibid., p. 504.
[3] Ann. der Phys., vol. 16, p. 614, 1905.
[4] Ann. der Phys., vol. 16, p. 603, 1905.

[5] Physical Review, vol. 25, p. 145-170, 1907.

value by 1 part in 1000, all of these results will be decreased by 2 parts in 1000. They will then be exprest in terms of the new unit as exactly as they are now given in international joules.

The results obtained are given in the accompanying Table 1, which is self-explanatory. The second column gives the temperature of the evaporating water. The weight of water evaporated is given in the third column, the observed weight being corrected for the buoyancy of the air. This buoyancy is less than it would be for the same amount of water by itself, inasmuch as the volume of the mixture of water and acid is less than the sum of their separate volumes. The exact density of the mixture was obtained from the latest tables of Landolt and Börnstein, and the corresponding correction applied to determine the true weight of the water *in vacuo*. I is the current thru the heating coil, E the fall of potential between its terminals, and L denotes the electrical energy expended for the evaporation of each gram of water.

TABLE 1.—*Collected data, giving the results obtained in each experiment.*

Date.	Water evaporated.		Duration.	Assuming E_{15}=1.43400 volts.		$L=\frac{EIT}{W}$
	Temperature.	Amount (reduced to vacuum).		E	I	
1907.	° C.	*Grams.*	*Seconds.*	*Volts.*	*Amperes.*	*Joules.*
February 7.	21.18	3.0651	7197	3.7609	.27725	2448.4
	21.19	3.0585	7197	3.7618	.27785	2455.1
	21.18	3.0723	7197	3.7621	.27747	2445.4
February 8.	21.16	3.0586	7197	3.7610	.27725	2453.6
	21.16	3.0743	7197	3.7617	.27721	2441.2
	21.16	3.0640	7197	3.7613	.27729	2449.9
	21.16	3.0595	7197	3.7614	.27721	2452.8
February 9.	21.20	3.0595	7197	3.7617	.27726	2453.4
	21.20	3.0644	7197	3.7613	.27725	2449.2
	21.20	3.0598	7197	3.7613	.27721	2452.5
March 9....	21.14	2.7827	7197	2.1514	.43997	2448.1
	21.15	1.9024	5008	2.0737	.43998	2445.0
March 16...	13.96	1.8581	7203	2.9000	.21998	2473.0
	13.95	2.1754	8404	2.9000	.21999	2464.6
	13.95	1.7885	6903	2.9001	.22000	2462.6
	13.95	1.9438	7504	2.9001	.22002	2463.3
March 23...	28.06	3.1023	7205	3.8118	.27503	2434.8
	28.06	3.1314	7265	3.8117	.27503	2432.2
	28.06	2.3032	5344	3.8119	.27504	2432.6
	28.06	2.3264	5403	3.8118	.27504	2434.9
April 6.....	39.80	3.2481	7202	3.9468	.27499	2406.6
	39.80	3.2548	7203	3.9470	.27500	2402.2

The mean value of the electrical energy required for the evaporation of one gram of water at each temperature is:

Temperature.	*Heat of evaporation.*
° C	Joules.
13.95	2465.9
21.17	2449.5
28.06	2433.6
39.80	2404.4

Altho only two values were obtained on March 9, yet these are especially valuable, as the calorimeter used on that date was one of the earlier forms. The resistance of the heating coil was much less, thus requiring a larger current than on other days. These two determinations are, therefore, free from any constant bias due to the particular form of calorimeter used. It will be noticed, however, that the results agree very closely with the others obtained at the same temperature.

Griffiths.—Some years ago Griffiths made an elaborate investigation[6] into the heat of evaporation of water. His original intention was to cover the range from 10° C. to 60° C., but only a few results at 30° C. and at 40° C. are given, and he says: "Had time permitted I should have performed more experiments, especially at 30° C.". His preliminary method was to draw dry air thru the water, but this failed to give concordant results, and the final determinations were made by the more common method of reduced pressure.

A weighed amount of water was placed in a glass tube within the calorimeter, and flowed out thru a fine opening as fast as it was evaporated. Heat was supplied by an electric current which was stopt, as nearly as possible, when the last of the water was evaporated. The experiments were conducted at a constant temperature and appear to have been very carefully performed. The heat furnished by the current was computed from the formula $H=E^2T/R$, the value of E being measured in terms of a Clark cell the electro-motive force of which was taken as 1.4342 volts at 15° C. He exprest his results in calories, using 4.199 for the mechanical equivalent of heat. Using the same factor to translate the results back into joules gives

2429.3 joules at 30.00° C., and
2403.6 joules at 40.15° C.,

when exprest in terms of 1.43400 volts for the Clark cell at 15° C.

Henning.—About a year ago there appeared[7] the account of an investigation for the range from 50° C. to 100° C. A few determinations were made at 30° C., but for some reason are given only one-eighth the weighting accorded to the determinations at each of the higher temperatures. The water was made to boil under reduced pressure, the vapor being condensed and weighed. Heat was supplied by an electric current and measured in terms of a Weston standard cell. Probably the results were obtained in terms of Reichsanstalt volts. They are exprest in 15° calories by means of the factor 4.188 joules per calorie. I have reduced them back to international joules by multiplying by this same factor and also by 1.0016.

Whether exprest in calories or joules, most of Henning's results appear rather high. This is very apparent at 100° C., where the familiar number 537 is exceeded by nearly two units. However, Henning is not alone in finding this larger value, and it may be that the accepted value is too low. Certain it is that this important constant should be redetermined with modern appliances and with a greater degree of precision than has yet been done.

Regnault.—In 1847 Regnault made a series of 23 experiments at temperatures between 63° C. and 88° C. Steam from his boiler, at somewhat reduced pressure, was condensed within a calorimeter, the heat given out being determined by measuring the rise in temperature of the calorimeter bath. The unit in which the results are exprest is determined by the range of temperature of the water in the calorimeter. In every experiment this was nearly the 15-degree calorie, and, therefore, not far from the mean calorie. As there is some question whether Regnault's temperatures were measured on the mercurial or the nitrogen scale, and, therefore, whether his results should be corrected for the varying specific heat of the water in his calorimeter, it seems best to record his results as he gave them—especially as the corrections, if applied, would alter the final result by less than one-tenth of one per cent.

Results at 100° C.—By far the greater number of experiments have been made with water boiling under atmospheric pressure. Regnault conducted a series of 44 experiments under varying conditions and with different calorimeters, obtaining results which are entirely concordant and the accuracy of which can hardly be questioned. Since "Regnault's calorie" is very nearly equal to the mean calorie his final result is practically exprest in mean calories.

Thirty years later, in 1877, Berthelot[8] devised a calorimeter for studying the heat of evaporation of liquids at their boiling points. The accuracy of the apparatus was tested by using water, which gave 635.2, 636.2, and 637.2 in three trials. The

[6] Phil. Trans., vol. 186 A, p. 261–342, 1895.

[7] Ann. der Phys., vol. 21, p. 849–878, 1906.

[8] Ann. Chem. et Phys., vol. 12, p. 558, 1877.

mean is 636.2 calories for the "total heat", or 536.2 for the heat of evaporation of water.

In a similar way, Louguinine[9], in 1896, devised an elaborate apparatus for use with other liquids, and tested it by using water. Four experiments gave 637.87, 635.59, 637.64, 638.53 with a mean of 637.26 calories. The temperatures are not given, but corresponding values computed from Regnault's formula give a mean of 637.0 calories.

At the end of Griffiths's paper is a short note by Joly[10] in which he gives the results of 10 experiments with the steam calorimeter. 12.8545 grams of water were warmed from 11.89° C. to 99.96° C. by the condensation of 2.0994 grams of steam. Using Regnault's value, $L=536.66$, for the heat obtained from each gram of this steam he finds for the mean specific heat of water over this range (12° to 100°) the value 0.99520. From the observations of Bartoli and Stracciati this number should be 0.9995, and from the curve of specific heat as determined by Barnes it is 0.99938. In order to have obtained these values Joly would have had to use $L=538.98$ and $L=538.90$ mean calories, respectively.

As noted above the results obtained by Henning are also high, being 538.9 mean calories at 100° C.

In view of such varying results it is extremely difficult to determine the most probable value for the heat of evaporation at 100° C. Apparently it is not below 537 or above 539, but even this is uncertain, and a more careful determination may show that it lies outside these limits. For the present, however, a mean value, 538, best represents this important constant.

Determinations above 100° C.—The only work above the boiling point is that of Regnault, who carefully investigated the range 119° C to 195° C. Indeed it is this portion of his work in which he felt the greatest confidence and from which he deduced the well-known formula, $L=606.5+.305\ t$. In all 73 experiments were made, and these have been collected into 12 groups for the purpose of appearing clearly on the curve of Fig. 1, where only the mean value of each group is shown. Since the value at 100° C. has been taken at 538, the portion of the curve for higher temperatures is steeper than the above equation would show. There is no reason why the two portions of the curve should not be continuous in the region of 100° C. and thus form one smooth curve thruout their entire length, but from these observations it can not be so drawn unless the work of Henning is to be entirely disregarded, and that of Regnault from 60° C. to 200° C. accepted with entire confidence. An accurate and reliable determination at 100° C. would thus determine the location of this curve for a considerable range on either side.

According to Callendar, Preston, and others, the heat of evaporation becomes zero at the critical temperature, which Cailletet and Colardeau found[11] to be 365° C. This would require a very sharp downward turn of the curve beyond the observations of Regnault. The exact location of the curve above 200° C. is, however, mere conjecture.

In the accompanying Table 2 are collected the results of these various investigations. The third column shows the average temperature at which the water was evaporated. The heat of evaporation, as reported by the authors themselves, is given in the next column. These values are not directly comparable, inasmuch as they are exprest in different kinds of "calories". In those experiments where the heat was supplied by means of an electric current I have computed the result in international joules, taking the legally authorized value of 1.434 volts for the electro-motive force of the Clark cell at 15° C. Since the actual value of the electro-motive force of a Clark cell at this temperature is, in all probability, nearer 1.433 volts, the results are reduced to this unit also. The values obtained by Regnault and by Joly are exprest directly in mean calories and require no further correction.

TABLE 2.—*Collected results of all investigators.*

Observer.	Number of experiments.	Temperature (Centigrade).	Result as reported.	Joules per gram.		Mean calories.
				$E=1.434$	$E=1.433$	
Dieterici	20	0.00	596.80	2498.0	2494.6	596.28
A. W. Smith	4	13.95	....	2465.9	2462.5	588.61
	12	21.17	....	2449.5	2446.1	584.69
	4	28.06	....	2433.6	2430.2	580.89
	2	39.80	....	2404.4	2401.0	573.91
Griffiths	7	30.00	578.70	2429.3	2425.9	579.86
	6	40.15	572.60	2403.6	2400.2	573.72
Henning	8	49.14	569.55	2389.0	2385.6	570.23
	6	64.85	559.47	2346.8	2343.4	560.14
	13	77.34	552.47	2317.4	2314.0	553.11
	24	89.29	545.76	2289.3	2285.9	546.40
	18	100.59	538.25	2257.8	2254.4	538.87
Regnault	8	68.0	556.4	....	....	556.4
	8	79.9	549.0	....	....	549.0
	7	85.8	544.8	....	....	544.8
	44	99.88	536.7	....	....	536.7
Joly	10	99.96	....	....	....	538.9
Regnault	3	120.3	521.7	....	....	521.7
	4	126.8	517.6	....	....	517.6
	11	135.9	511.9	....	....	511.9
	13	145.2	504.9	....	....	504.9
	10	155.5	495.7	....	....	495.7
	5	162.4	491.5	....	....	491.5
	14	175.2	482.3	....	....	482.3
	9	185.6	478.1	....	....	478.1
	4	194.6	471.0	....	....	471.0
Cailletet	....	365.	....	....	....	(zero)

The mechanical equivalent of heat.—When it comes to translating the results here collected from the electrical units, "joules", into heat units, "calories", it is necessary to use the constant known as the mechanical equivalent of heat. And since the specific heat of water is not constant, but has a different value for each temperature, it is necessary to define precisely what is meant by the term "calorie". The unit used in this paper is the "mean calorie", that is, one per cent of the heat that is required to warm one gram of pure water from 0° C. to 100° C.

The mechanical equivalent of heat has been determined by several investigators. The classic experiment of Joule paved the way for the more precise measurements of Rowland, who worked on a larger scale and used an engine to stir the water in his calorimeter, thereby warming it more rapidly. This investigation was conducted with masterly precision and gives one of the best determinations of the mechanical equivalent over the range 5° C. to 35° C.

More recently Reynolds and Moorby[12] have directly measured the amount of mechanical work required to warm pure water from the freezing to the boiling point. The care and precaution observed in their work, and the minute discussion of possible sources of error, warrant unusual confidence in their result. Ice-cooled water was past in a continuous stream thru a hydraulic brake dynamometer consisting of a central disk carrying vanes on each side and running between similar stationary vanes. The terrific stirring experienced by this water warms it, and by properly regulating the rate of flow it could be made to leave the brake at any desired temperature. In these experiments a single brake absorbed the power of three large engines, and the flow of water was regulated to leave the brake at very nearly 212° F. and under sufficient pressure to prevent the formation of steam. The measured amount of heat is thus independent of all thermometric scales, thermometers being used only to identify the freezing and boiling

[9] Ann. Chem. et Phys., vol. 7, p. 251-252, 1896.
[10] Phil. Trans., vol. 186A, p. 322, 1895.
[11] Comptes Rendus, t 112, p. 563, 1891.
[12] Phil. Trans., vol. 190A, p. 300-422, 1897.

points. In order to eliminate constant errors as far as possible, a set of experiments of one hour each in which small power was employed was followed by a similar set in which two or three times as much power was used. Since the temperatures, speeds, etc., were the same for each set many uncertainties would be the same in each case. Therefore, the final result is computed considering only the *difference* in the works and the *difference* in the heats in the two cases. Every possible source of error was carefully examined, the weighings were reduced to vacuum, and account taken of the air dissolved in the water.

Exprest in absolute units, the work required to warm one gram of water from the freezing to the boiling point was found to be 4.1832×10^7 ergs, or 4.1832 joules, per degree centigrade. Inasmuch as this covered nearly the entire range of temperature from 0° C. to 100° C. no correction was required for the varying specific heat of water. But an examination of the details of the experiments shows that the mean range of temperature was from about 1° C. to 100° C., and according to Barnes the average specific heat from 1° C. to 100° C. is less than that from 0° C. to 100° C. by 1 part in 10,000. Applying this slight correction gives for the mechanical equivalent of a mean calorie, the value

$$J = 4.1836 \text{ joules.}$$

Another method of determining this constant is to warm the water by means of an electric current. The principal investigations are those of Griffiths, Schuster and Gannon, and Callendar and Barnes. In the first two investigations water was warmed in a calorimeter. In the work of Callendar and Barnes everything was maintained at a constant temperature, a steady electric current in a platinum wire warming a continuous stream of water. The electrical energy was determined by measuring the current and the fall of potential over the wire, each in terms of a standard Clark cell. The results as first reported by these physicists were somewhat too large, owing to the fact that the electro-motive force of their Clark cell was taken as 1.4342 volts at 15° C. In a critical discussion of this entire subject before the International Electrical Congress at St. Louis in 1904, Professor Barnes[13] gives the results as recalculated on the basis of 1.43325 volts at 15° C. for the Clark cell. I have plotted Barnes's values from 0° C. to 100° C. and very carefully integrated the resulting curve in order to determine the mean value over this range of temperature. The result gives 4.1846 joules per mean calorie, which is slightly smaller than the arithmetical mean of the 21 values given by Barnes, inasmuch as in the arithmetical mean the first and last values receive twice the weight given to intermediate values.

At the present time the most probable value for the electromotive force of a Clark cell at 15° C. is 1.433 volts. This means that the above result should be still further reduced, even in the ratio of $(1.43325)^2$ to $(1.43300)^2$, since the electrical energy was computed by the formula *EIT*, and both *E* and *I* were measured in terms of the Clark cell. Making this correction gives

$$J = 4.1846 \times \frac{(1.43300)^2}{(1.43325)^2} = 4.1832 \text{ joules.}$$

Rowland, by the mechanical method, and Griffiths and Schuster and Gannon, by the electrical method, found slightly larger values than this. The reason for any discrepancy has not yet been explained, but is usually considered due to the different methods of calorimetry. Inasmuch as Reynolds and Moorby and Callendar and Barnes both used the "continuous method", in which there is no change of temperature in any part of the apparatus while the heat is carried away in a continuous stream of water, it would seem as tho their results would be the more directly comparable. And since I have used a similar method and have avoided all changes in temperature, the most applicable value of J is that determined by Reynolds and Moorby, *provided* the electro-motive force of the Clark cell at 15° C. is taken as 1.433 volts. The values in the first half of the last column, "mean calories", of Table 2 are computed by means of the factor, $J = 4.1836$.

The results of all these investigations were carefully plotted on a sheet of accurately engraved cross-section paper, and the smooth curve which most nearly represents all the values was drawn. (See fig. 1.) From the curve were then determined the values of the heat of evaporation for each five-degree point from 0° C. to 100° C. and for each ten-degree point from 100° C. to 200° C.

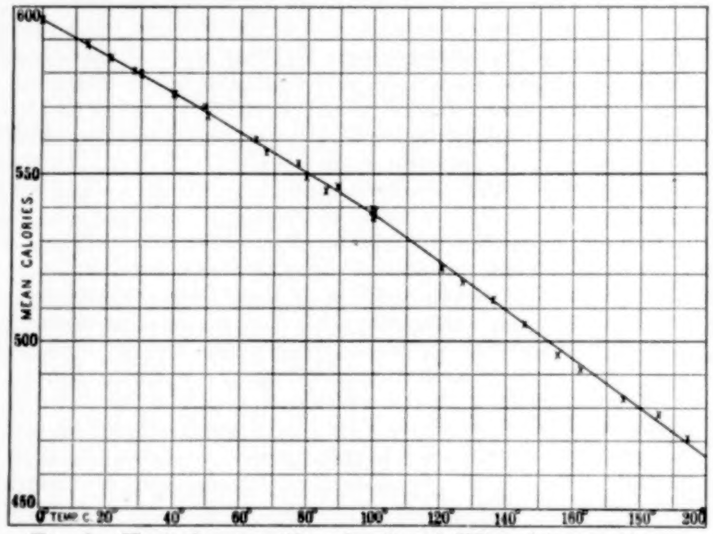

FIG. 1.—Heat of evaporation of water at different temperatures.

TABLE 3.—*Heat of evaporation of water.*

Temperature.	Heat required to evaporate one gram.		
	Joules.	Mean calories.	20°-calories.
°C.	E=1.4330	J=4.1836	J=4.1773
0	2494.6	596.3	597.2
5	2483.4	593.6	594.5
10	2472.1	590.9	591.8
15	2460.4	588.1	589.0
20	2448.7	585.3	586.2
25	2437.0	582.5	583.4
30	2425.2	579.7	580.6
35	2413.5	576.9	577.8
40	2401.4	574.0	574.9
45	2389.3	571.1	572.0
50	2377.1	568.2	569.1
55	2365.0	565.3	566.2
60	2352.4	562.3	563.2
65	2339.9	559.3	560.2
70	2327.3	556.3	557.1
75	2314.8	553.3	554.1
80	2302.2	550.3	551.1
85	2289.7	547.3	548.1
90	2277.1	544.3	545.1
95	2264.2	541.2	542.0
100	2250.8	538.0	538.8
110	2220.7	530.8	531.6
120	2190.1	523.5	524.3
130	2159.6	516.2	517.0
140	2129.5	509.0	509.8
150	2099.3	501.8	502.6
160	2069.2	494.6	495.3
170	2038.7	487.3	488.0
180	2008.5	480.1	480.8
190	1978.4	472.9	473.6
200	1948.3	465.7	466.4
365	Heat of evaporation vanishes.		

While it is possible to write the equation of this curve, such a formula would be of doubtful value. It is better to show the actual curve and the points among which it is drawn, for this will be less likely to give the appearance of unwarranted accuracy or completeness. Above 100° C. we have only the work of Regnault, performed sixty years ago. At 100° C. are several points, differing by more than seems

[13] Trans. Int. Elec. Congress, 1904, vol. I, p. 65.

necessary, and there is also a sharp bend in the curve at this point. The lower part of the curve seems to be very definitely determined, and below 50° C. there is unanimous agreement among the various investigators.

Calorimetric investigations are frequently conducted at room temperatures and the results exprest in terms of the "calorie at 20° C.". For this reason the values in the last column of Table 3 are given. They are computed from the values in the preceding column by means of the factor $\frac{4.1846}{4.1783}$, obtained from the variation curve of Barnes. The 15-degree calorie may be taken as equal to the mean calorie.

If the finally accepted value for the Clark cell at 15° C. is not 1.433 volts, then a new calculation of the above values from the data in the original papers will be in order. But until this point is definitely settled, these values are the best available for all those who have occasion to use the heat of evaporation of water, either by itself or as a correction factor in other investigations.

INTERESTING OLD METEOROLOGICAL LITERATURE.

The Meteorological Library of the Johns Hopkins University desires to secure as complete a set as possible of the early publications of our various State weather service organizations. Before the present systematic uniformity was introduced by Professor Moore these State publications were of various sizes, shapes, and styles; and many of them were personal matters by our local observers, encouraged by General Greely and Professors Harrington and Moore as leading up to State organizations. Any one who has either whole sets or odd numbers of these old monthly sheets that he will present to the above-mentioned meteorological library should mail them to Dr. Nicholas Murray, Librarian, Baltimore, Md.

The pioneers in these personal enterprises were (1) Kerkam and Hunt, at New Orleans, La., 1891 and 1892; (2) Moore, at Milwaukee, Wis., 1892; (3) Hunt, at Omaha, Nebr., 1893–94; (4) Beals, at Minneapolis, Minn.; (5) Hunt, at Atlanta, Ga., 1894–95; and the publications for these years would be of great historical interest. Besides these publications by Signal Service men personally, we may also note those of an official character by the State weather services established about 1885 and subsequently.

FIRE AT MOUNT WEATHER.

About 4 a. m. on the morning of Wednesday, October 23, 1907, fire was discovered in the administration building at Mount Weather. Altho it had already gained much headway, the occupants escaped with little difficulty, except one who sustained severe injuries by jumping from a window. It was useless to try to check the flames and there was time to save no Government property and scarcely any private belongings. The building was totally destroyed, causing a loss of about $25,000 to the Government on building, furnishings, instruments, etc., and about $6,500 to the occupants.

All books and records in the building were destroyed, including the only copies of the regular meteorological records from the first of the month, and some records of special investigations which had not been copied or worked up for publication, and which are therefore completely and irreparably lost. The loss in the way of instruments is far less serious; for the exposed thermometers, thermograph, and gages, tho near the building, were unharmed; and the equipment for upper air research and the valuable instruments for investigations in terrestrial magnetism and solar radiation were in distant buildings and therefore unaffected.

Altho several of the men were compelled to borrow clothing from their more fortunate comrades and from neighbors, yet the daily work of kite flying and observations was immediately resumed on the day of the fire, and has suffered no interruption. A meteorological observatory has been temporarily installed in the power house. and telegraphic communication with Bluemont and Washington was speedily restored.

ICE COLUMNS IN GRAVELLY SOIL.

We have lately learned that a very important article on this subject was published a few years ago, in the Japanese language, and we shall endeavor to obtain a translation or abstract thereof. Meantime those interested in the subject will perhaps be glad to add the following title to the bibliography of the subject.

Report of investigation of ice columns by Prof. M. Goto, Higher Normal School, Tokyo, Japan, and Prof. O. Inagaki, Higher Agricultural School, Morioka, Japan. In the "Toyo Gakugei Zasshi" (Oriental Science Monthly), Vol. 16, 1900, Nos. 211, 212, and 213; 38 pages; 12 experiments.

This memoir contains:

Chapter I. Introduction.
- II. Facts known to previous investigators.
- III. Facts made known by our investigations.
  - i. Reasons why ice columns grow upward.
  - ii. Upward pressure of the growing ice columns.
  - iii. The morphology of the ice columns.
    - *a.* Forms of ice columns.
    - *b.* Density of ice columns.
    - *c.* Specific gravity of ice columns.
    - *d.* Limit of growth of ice columns.
    - *e.* Damage done by these ice columns.
    - *f.* Relations of soils and the growth of ice columns.

PLEASE ANSWER THESE QUERIES PROMPTLY.

The Editor has been asked to what extent he can diminish the size of the MONTHLY WEATHER REVIEW, and how he can improve its value to its readers. Considered as a meteorological journal it must necessarily contain a wide range of material. It is consulted by teachers, engineers, climatologists, and special students of a variety of topics, and the Editor wishes to submit to these the question what can be done to remove unnecessary material and improve the general value of the publication.

Will not each reader, whether domestic or foreign, kindly consider the following questions as addrest to him personally, and reply by return mail to the Editor?

(*A*) Are the following features of so much interest to you as to be worth publishing, either for your own personal use or in the general interest of meteorology?

1. The chapter on forecasts and warnings.
2. The section on rivers and floods.
3. The special articles, notes and extracts.
   - *a.* Popular.
   - *b.* Educational.
   - *c.* Technical.
   - *d.* Bibliographical.
   - *e.* Seismological.
4. The chapter on "The weather of the month".
5. The climatological summary.
6. Table I. Climatological data.
7. Table II. Climatological record.
8. Table III. Wind resultants.
9. Table IV. Excessive precipitation.
10. Table V. Canadian data.
11. Table VI. Heights of rivers.
12. Honolulu data.
13. Jamaica rainfall.
14. Chart I. Hydrographs for seven principal rivers.
15. Chart II. Paths of areas of high pressure.
16. Chart III. Paths of areas of low pressure.
17. Chart IV. Total precipitation.
18. Chart V. Daytime cloudiness.
19. Chart VI. Isobars and isotherms at sea level and resultant surface winds.
20. Chart VII. Total depth of snowfall.
21. Chart VIII. Amount of snow on ground.

(*B*) If you get the equivalent of the tables, or so much of them as are interesting or useful to you, in the monthly section reports, or the Annual Report of the Chief of Bureau, in form more serviceable to you, please so state.

(*C*) Is there any feature or subject not yet introduced into the REVIEW that you wish us to take up?

(*D*) Is your copy of the REVIEW destroyed, preserved for future use, or deposited in some library?

STUDIES ON THE VORTICES IN THE ATMOSPHERE OF THE EARTH.

By Prof. FRANK H. BIGELOW.

I.—THE APPLICATION OF THE THEORY OF VORTEX MOTION TO THE FUNNEL-SHAPED WATERSPOUT AT COTTAGE CITY, AUGUST 19, 1896.

INTRODUCTORY REMARKS.

The purpose of the series of papers on the thermodynamics of the atmosphere, which appeared in the MONTHLY WEATHER REVIEW during the year 1906, was to indicate the distribution of the masses of air of different temperatures in the neighborhood of the axes of cyclones, anticyclones, and a typical waterspout, and to develop the formulas which are useful in discussing the energy contained in them, available in the restoration to a thermal equilibrium under the action of gravity. When a sheet of relatively cold air overlies a sheet of relatively warm air there will be an interchange of position, and in changing places there will be a development of certain stream lines which it is important to understand as fully as possible. Such a distribution of stratified air is an efficient cause of the formation of the vortices popularly called the tornado, the waterspout, and the hurricane. There are two types of such vortices prevailing in the earth's atmosphere, each of which is represented in the Cottage City waterspout of August 19, 1896.[1] The first type is seen in the second appearance, as on Chamberlain's photograph, 2d A, and the second type is found in the third appearance, as on Chamberlain's photograph, 3d A. It will be shown that the St. Louis tornado, May 27, 1896, and the De Witte typhoon, August 1–3, 1901, belong to the first, or dumb-bell, type, while many small funnel-shaped tornadoes belong to the second type. These typical examples will be fully worked out, and the velocities, radial (u), tangential (v), and vertical (w), computed, together with the various relations connecting them together. When two masses of air of different temperatures lie side by side the stream lines which are generated in the thermal flow are of a very different type from those of the preceding cases, in so far as the cyclone represents a pure vortex motion of any type. The general vortices in the earth's atmosphere or other atmospheres belong to still other classes. These vortices were summarized on pages 512, 513, of the International Cloud Report,[2] and in the MONTHLY WEATHER REVIEW, January, 1904;[3] but in this present series of papers an attempt will be made to find the constants and the velocities existing in these specific examples. The final step in the solution of this class of problems will consist in correlating the observed temperature and pressure conditions with these computed velocities. It will be important to develop the computations in detail, so that meteorologists may be able to discuss the circulations of the air as practical examples of the interchange of energy in the atmosphere. The knowledge already attained regarding the temperatures in the earth's atmosphere justifies us in making an effort to advance these fundamental problems in dynamical meteorology. It seems to me quite probable that the best way to determine the physical constants belonging to the sun's atmosphere, i. e., the specific heats and the temperature gradients, will be by utilizing the visible surface velocities of the solar vortex, which is a function of the same.

[1] See Monthly Weather Review for July, 1906, p. 307–315, and plates.

[2] Report of the Chief of the Weather Bureau, 1898–99, Vol. II. Hereafter this is referred to as "Cloud Report," or merely "C. R."

[3] Vol. XXXII, p. 15–20.

THE FORMULAS OF VORTEX MOTION.

The subject of vortex motion applicable to the earth's atmosphere may be conveniently referred to in the following works:

1. Basset's Treatise on Hydrodynamics, Vol. II, pp. 34–94, 1888.
2. Lamb's Hydrodynamics, pp. 222–265, 1895.
3. Wien's Lehrbuch der Hydrodynamik, pp. 54–83, 1900.
4. Bigelow's Summary of Formulas, Cloud Report, pp. 508–513, 1898.

Since the notation differs in these treatises the following table of equivalents is added:

TABLE 1.—*Equivalent systems of notation.*

Functions.	Basset.	Lamb.	Wien.	Bigelow.
Total differential	∂	∂	d	d
Partial differential	d	d	∂	∂
Differential increment	δ	δ	δ	δ
Finite difference	Δ	Δ	Δ	Δ
Rectangular coordinates	y, z, x	y, z, x	x, y, z	x, y, z
Cylindrical coordinates	ϖ, θ, z	ϖ, ϑ, x	ρ, ϑ, z	ϖ, ϕ, z
Polar coordinates	r, θ, ϕ	r, θ, ω	r, ϑ, Θ	r, θ, λ
Rectangular velocity	v, w, u	v, w, u	u, v, w	u, v, w
Cylindrical velocity	v, w, u	v, w, u	r, ϖ, η, w	u_1, v_1, w_1
Polar velocity	V, W, U	v, w, u	....	u_2, v_2, w_2
Angular velocity	η, ζ, ξ	η, ζ, ξ	ξ, η, ζ	$\omega_1, \omega_2, \omega_3$
Current function	Right hand. $+\psi$	Right hand. $-\psi$	Left hand. $+\psi$	Right hand. $+\psi$
Velocity potential	$+\phi$	$-\phi$	$+\phi$	$+\phi$
Static potential	$+V$	$+V$	$-V$	$+V$
Vortical coordinates	M, N, L	G, H, F	U, V, W	F, G, H
Kinetic energy	T	T	L	T
Potential energy	V	V	F	U
Density	ρ	ρ	s	ρ
Viscosity coefficient	$\nu = \frac{\mu}{\rho}$	μ	k^2	μ

Bigelow and Wien take the z-axis as the axis of rotation in cylindrical coordinates, while Basset and Lamb use the x-axis. Wien has left-hand rotation and the others right-hand.

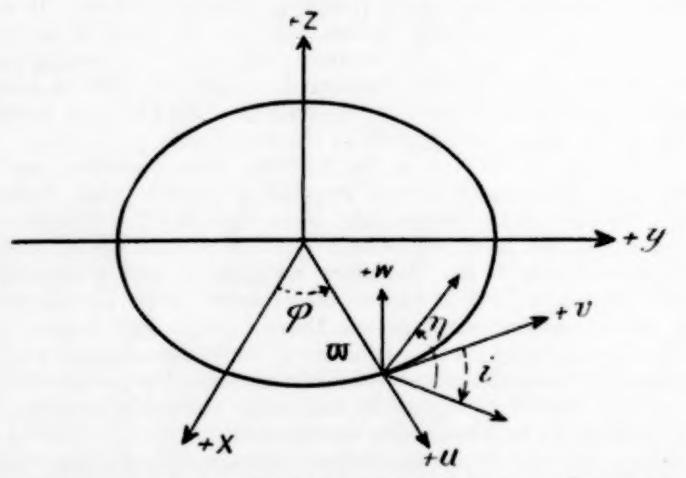

FIG. 1.—Rectangular coordinates of any point are x, y, z. Cylindrical coordinates of the same point are ϖ, ϕ, z. Velocities at that point (ϖ, ϕ) are u, v, w. Angles at that point (ϖ, ϕ) are i, η.

TABLE 2.—*Equations in cylindrical coordinates.*

(Compare equations 152, 160, 161, 162, 163, 165......pp. 497, 499, 500, Cloud Report.)

(1) Linear displacements. Cloud Report 152.

$$\begin{cases} \partial x = u\partial t = \partial \varpi. & x = \varpi \cos \varphi. \\ \partial y = v\partial t = \varpi \partial \varphi. & y = \varpi \sin \varphi. \\ \partial z = w\partial t = \partial z. & \end{cases}$$

(2) Angular velocities and forces in symmetrical motion about the z-axis. Cloud Report 160.

$$\begin{cases} \omega_1 = 0. \\ \omega_2 = 0. \\ \omega_3 = + \dfrac{v}{\varpi}. \end{cases} \qquad \begin{cases} -\dfrac{\partial V}{\partial x} = -\dfrac{\partial V}{\partial \varpi} = 0. \\ -\dfrac{\partial V}{\partial y} = -\dfrac{\partial V}{\varpi \partial \varphi} = 0. \\ -\dfrac{\partial V}{\partial z} = -g. \end{cases}$$

(3) Linear velocities. Cloud Report 152.

$$\begin{cases} u = \dfrac{dx}{dt} = u_1 \cos \varphi - v_1 \sin \varphi. \\ v = \dfrac{dy}{dt} = u_1 \sin \varphi + v_1 \cos \varphi. \end{cases}$$

(4) Linear velocities with moving axes in cylindrical coordinates. Cloud Report 160.

$$\begin{cases} u_1 = \dfrac{\partial \varpi}{\partial t} - y\omega_3 + z\omega_2. \\ v_1 = \varpi \dfrac{\partial \varphi}{\partial t} - z\omega_1 + x\omega_3. \\ w_1 = \dfrac{\partial z}{\partial t} - x\omega_2 + y\omega_1. \end{cases}$$

(5) Angular velocities omitting the subscripts in u_1, v_1, w_1. Cloud Report 162.

$$\begin{cases} 2\omega_1 = \dfrac{\partial w}{\varpi \partial \varphi} - \dfrac{\partial v}{\partial z}. \\ 2\omega_2 = \dfrac{\partial u}{\partial z} - \dfrac{\partial w}{\partial \varpi}. \\ 2\omega_3 = \dfrac{\partial v}{\partial \varpi} - \dfrac{\partial u}{\varpi \partial \varphi} + \dfrac{v}{\varpi}. \end{cases}$$

(6) General equations of motion symmetrically about the z-axis. Cloud Report 161.

$$\begin{cases} -\dfrac{\partial V}{\partial \varpi} - \dfrac{\partial P}{\rho \partial \varpi} = \dfrac{\partial u}{\partial t} + u\dfrac{\partial u}{\partial \varpi} + w\dfrac{\partial u}{\partial z} - \dfrac{v^2}{\varpi}. \\ 0 = \dfrac{\partial v}{\partial t} + u\dfrac{\partial v}{\partial \varpi} + w\dfrac{\partial v}{\partial z} + \dfrac{uv}{\varpi}. \\ -\dfrac{\partial V}{\partial z} - \dfrac{\partial P}{\rho \partial z} = \dfrac{\partial w}{\partial t} + u\dfrac{\partial w}{\partial \varpi} + w\dfrac{\partial w}{\partial z}. \end{cases}$$

(7) Equation of continuity. Cloud Report 165.

$$\left\{ \frac{\partial(\varpi u)}{\partial \varpi} + \frac{\partial V}{\partial \varphi} + \varpi \frac{\partial w}{\partial z} = \frac{\partial u}{\partial \varpi} + \frac{u}{\varpi} + \frac{\partial w}{\partial z} = 0. \right.$$

(8) General equations of motion on the rotary earth. Cloud Report 165.

$$\begin{cases} -\dfrac{\partial P}{\rho \partial \varpi} = \dfrac{du}{dt} - 2n\cos\theta \cdot v - \dfrac{v^2}{\varpi} + ku. \\ -\dfrac{\partial P}{\rho \varpi \partial \varphi} = \dfrac{dv}{dt} + 2n\cos\theta \cdot u + \dfrac{uv}{\varpi} + kv. \\ -\dfrac{\partial P}{\rho \partial z} = \dfrac{dw}{dt} + g. \end{cases}$$

(9) It is convenient usually to take the positive direction of the z-axis upward, but to place the plane $x\,y$ below the sea-level surface.

The velocity coordinates u, v, w in forms of the current function ψ.

In discussing problems in vortex motion, it is convenient to use the current function ψ, which is deduced from the equation of continuity. This equation is:

$$(10) \qquad \frac{\partial u}{\partial \varpi} + \frac{u}{\varpi} + \frac{\partial w}{\partial z} = 0,$$

and it may take the form,

$$(11) \qquad \frac{1}{\varpi}\frac{\partial}{\partial \varpi}(u\varpi) + \frac{\partial w}{\partial z} = 0.$$

This is satisfied by substituting the velocities,

$$(12) \qquad u = -\frac{1}{\varpi}\frac{\partial \psi}{\partial z}, \quad w = +\frac{1}{\varpi}\frac{\partial \psi}{\partial \varpi},$$

which are known as Stokes's functions.

In order to satisfy the second equation of motion in 161, where the motion is steady and $\dfrac{\partial v}{\partial t} = 0$, the value of v is,

$$(13) \qquad v = \frac{\psi}{\varpi},$$

so that $\psi = v\varpi$ is the constant in vortex motion.

Substituting these values of u, v, w in $(161)_2$, we have,

$$(14) \qquad -\frac{1}{\varpi^2}\frac{\partial \psi}{\partial \varpi}\frac{\partial \psi}{\partial z} + \frac{1}{\varpi}\frac{\partial \psi}{\partial z}\frac{\psi}{\varpi^2} + \frac{1}{\varpi^2}\frac{\partial \psi}{\partial z}\frac{\partial \psi}{\partial \varpi} - \frac{1}{\varpi}\frac{\partial \psi}{\partial z}\frac{\psi}{\varpi^2} = 0.$$

In the case of steady motion, if the second equation of 161 is multiplied by ϖ, we have,

$$(15) \qquad uv + u\varpi\frac{\partial v}{\partial \varpi} + w\varpi\frac{\partial v}{\partial z} + wv\frac{\partial \varpi}{\partial z} = 0.$$

Since $\frac{\partial \varpi}{\partial z} = 0$, it may also be written,

(16) $$u \frac{\partial}{\varpi}(\varpi v) + w \frac{\partial}{\partial z}(\varpi v) = 0.$$

This shows that $\psi = v\varpi =$ constant is a solution and develops the vortex law required. Any function of ψ which satisfies this equation will be a solution of the second equation of motion.

(17) Hence, $\varpi v = f(\psi) =$ an arbitrary function of ψ, is a solution of the second equation of motion.

We can eliminate the potential and pressure terms from the first and third equations of motion by differentiating the first to z, the third to ϖ, subtracting and substituting the angular velocity, $2\omega_z = \frac{\partial u}{\partial z} - \frac{\partial w}{\partial \varpi}$, in terms of ψ. Following these precepts we obtain the general vortex equation.

(18) $$0 = \frac{\partial}{\partial t}\left(\frac{\partial u}{\partial z} - \frac{\partial w}{\partial \varpi}\right) + \frac{\partial u}{\partial \varpi}\left(\frac{\partial u}{\partial z} - \frac{\partial w}{\partial \varpi}\right) + \frac{\partial w}{\partial z}\left(\frac{\partial u}{\partial z} - \frac{\partial w}{\partial \varpi}\right) - \frac{\partial}{\partial z}\left(\frac{v^2}{\varpi}\right).$$

The following auxiliaries are found from u and ϖ,

(19) $$\frac{\partial u}{\partial \varpi} = -\frac{\partial}{\partial \varpi}\frac{1}{\varpi}\frac{\partial \psi}{\partial z}. \qquad v\varpi = f(\psi).$$

(20) $$\frac{\partial w}{\partial z} = +\frac{\partial}{\partial z}\frac{1}{w}\frac{\partial \psi}{\partial \varpi}. \qquad \frac{v^2}{\varpi} = \frac{[f(\psi)]^2}{\varpi^3}$$

(21) $$2\omega_z = \left(\frac{\partial u}{\partial z} - \frac{\partial w}{\partial \varpi}\right) = -\frac{1}{\varpi}\left(\frac{\partial^2 \psi}{\partial \varpi^2} - \frac{1}{\varpi}\frac{\partial \psi}{\partial \varpi} + \frac{\partial^2 \psi}{\partial z^2}\right)$$

Making the substitutions, we obtain

(22) $$0 = \frac{\partial}{\partial t}(2\omega_z) + \frac{\partial u}{\partial \varpi}(2\omega_z) + \frac{\partial w}{\partial z}(2\omega_z) - \frac{\partial}{\partial z}\frac{[f(\psi)]^2}{\varpi^3}$$

Hence,

(23) $$0 = \frac{1}{\varpi}\frac{\partial}{\partial t}\left(\frac{\partial^2 \psi}{\partial \varpi^2} - \frac{1}{\varpi}\frac{\partial \psi}{\partial \varpi} + \frac{\partial^2 \psi}{\partial z^2}\right) + \frac{\partial \psi}{\partial z} \cdot \frac{\partial}{\partial \varpi}\left[\frac{1}{\varpi^2}\left(\frac{\partial^2 \psi}{\partial \varpi^2} - \frac{1}{\varpi}\frac{\partial \psi}{\partial \varpi} + \frac{\partial^2 \psi}{\partial z^2}\right)\right]$$
$$- \frac{\partial \psi}{\partial \varpi} \cdot \frac{\partial}{\partial z}\left[\frac{1}{\varpi^2}\left(\frac{\partial^2 \psi}{\partial \varpi^2} - \frac{1}{\varpi}\frac{\partial \psi}{\partial \varpi} + \frac{\partial^2 \psi}{\partial z^2}\right)\right] - \frac{2f(\psi)\frac{\partial f(\psi)}{\partial z}}{\varpi^3}.$$

Any function of ψ satisfying this equation is capable of giving a vortex motion. In the application to the atmospheres of the earth and the sun some simple forms will be considered and illustrated by examples from the observations. Inasmuch as it is not possible to make observations in all parts of the tornadoes, hurricanes, and cyclones, it has been very difficult to secure the values of the constants entering into the formulas, but it is thought that this trouble has now been overcome. The simultaneous operation of the current function ψ in equations (17) and (23) is necessary in order to combine the velocities u, v, w in a consistent vortical motion. That we may make it clear in what respects the solutions adopted in these papers differ from other solutions found in previous discussions, the following brief recapitulation is summarized from my Cloud Report, 1898–99, p. 595–603.

Ferrel's solution.—Ferrel took the second equation of (8), and for assumed symmetry about the z-axis with no friction, $kv=0$, reduced it to the form,

(24) $$\frac{dv}{dt} + (2n\cos\theta + \nu_1)\,u = 0.$$

From this by integration within a fixt cylindrical surface of radius ϖ_0, he deduced the tangential velocity

(25) $$v = \left(\frac{\varpi_0^2}{2\varpi^2} - 1\right)\varpi n \cos\theta,$$

at the distance ϖ from the axis. The angle of divergence of the stream line on the horizontal plan from the tangent to the isobar, in terms of the coefficient of the deflecting force, $\lambda = 2n\cos\theta$, and the coefficient of friction k, is deduced to be, for $\frac{du}{dt} = 0$,

(26) $$\tan i = \frac{k}{\lambda + \frac{v}{\varpi}}$$

This signifies that the cause of the departure of the currents entering the closed isobars is the effect of the friction and the deflecting force upon the tangential component. But we shall show that the angle i is due to an entirely different set of circumstances as a primary cause, tho its normal value on a given level or stratum may be slightly modified by these two auxiliary forces.

The German solution.—The second equation of motion has generally been discust in a different manner by the German meteorologists, who have used two other solutions of which it is capable when the fuller form is employed, namely,

(27) $$\frac{\partial v}{\partial t} + \frac{uv}{\varpi} + \lambda u + kv = 0.$$

These two-type solutions are common to the works of Guldberg and Mohn, Sprung, Oberbeck, Pockels, and others, wherein Oberbeck and Pockels have introduced modifying factors into the simple solution of Guldberg and Mohn or Sprung. One solution is taken applicable to the inner part of a cyclone, and the other to the outer part.

		First solution (inner part).	Second solution (outer part).
(28)	Radial velocity	$u = -\frac{c}{2}\varpi.$	$u = -\frac{c}{\varpi}$
(29)	Tangential velocity	$v = +\frac{\lambda}{k-c}\cdot\frac{c}{2}\varpi z.$	$v = +\frac{\lambda}{k}\frac{c}{\varpi}z$
(30)	Vertical velocity	$w = +cz.$	$w=0$
(31)	Angle of inclination,	$\tan i = \frac{u}{v} = -\frac{k-c}{\lambda z}.$	$\tan i = \frac{u}{v} = -\frac{k}{\lambda z}$
(32)	Current function $(u.w)$	$\psi_1 = \frac{c}{2}\varpi^2 z.$	$\psi_1 = cz$
	Current function (v)	$\psi_2 = \frac{c}{2}\frac{\lambda}{k-c}\varpi^2 z.$	$\psi_2 = c\frac{\lambda}{k}z$

It is seen that these solutions depend upon three constants: k, the coefficient of friction; λ, the coefficient of the deflecting force due to the earth's rotation; and c, the coefficient of the vertical distance z from the plane of reference, in order to produce the observed angle of inclination. The current functions derived from these solutions are, however, inconsistent. If Stokes's functions be applied to u and w in the first solution, then $\psi_1 = \frac{c}{2}\varpi^2 z$; but if the vortex law, $\psi = v\varpi =$ constant, is used, then $\psi_2 = \frac{c}{2}\frac{\lambda}{k-c}\varpi^2 z$, which is a different value of ψ. In the same way, by means of Stokes's functions, $(u\ w)$ give for the

current function $\psi_1 = cz$, while the vortex law $\psi_2 = v\varpi = c\frac{\lambda}{k}z =$ a constant, but differing in value from ψ_1. Hence, $\psi_2 =$ const. ψ_1; or $\psi_2 =$ const. ψ_1. In nature, there is no outer part of a cyclone where $w = 0$, and there is no boundary where the law of motion changes suddenly from the parabolic type, $\frac{v}{\varpi} =$ constant, to the hyperbolic type, $v\varpi =$ constant, as is called for in these solutions. Nor is it possible that the natural values of k, λ, c can account for the observed angle i in all levels, and they are by no means constant even on the same vortex tube.

SOLUTION FOR THE FUNNEL-SHAPED VORTEX TUBE. COTTAGE CITY WATERSPOUT, CHAMBERLAIN 3d A.

Since my solution for the vortex represented in Chamberlain's photograph 3d A of the Cottage City waterspout, MONTHLY WEATHER REVIEW, July, 1906, Plate VIII, approximates the type which is involved in the first solution, inner part, as applied by the German meteorologists to the cyclone, I will take up that problem before the others, and will then illustrate the other type by Chamberlain's 2d A, Plate I, the St. Louis tornado, and the De Witte typhoon. The ocean cyclone and the land cyclone are impure vortices of the latter type. Unfortunately, by adopting the present procedure it is not possible at the outset to demonstrate my method of finding the values of the constants required in the evaluation of the formulas in this special case. Having only the photograph of the tube, which gives the outline of the vortex, but no idea of the velocities in the several directions, it has been exceedingly difficult to discover what the vortex constants are in nature. They were finally obtained by starting with the hurricane, and advancing thru the tornado and the second waterspout vortex to the first type now under consideration. Many efforts were made before this successful result was obtained, the outcome being now checked by reproducing a vortex whose dimensions agree closely with that represented in the photograph when the latter is translated into meters by the scale already found to apply, namely, *1 millimeter on the photograph = 18.3 meters at the waterspout.* The derivation of the formulas is very simple after the form of the vortex function has been determined. That form which is applicable to the funnel-shaped vortex tube is,

$$(33) \qquad \psi = C\varpi^2 z.$$

From this formula we find by differentiation,

$$(34) \qquad \frac{\partial\psi}{\partial\varpi} = 2C\varpi z, \qquad \frac{\partial^2\psi}{\partial\varpi^2} = 2Cz, \text{ and,}$$

$$(35) \qquad \frac{\partial\psi}{\partial z} = C\varpi^2, \qquad \frac{\partial^2\varpi}{\partial z^2} = 0, \quad \text{so that,}$$

$$(36) \qquad \frac{\partial^2\psi}{\partial\varpi^2} - \frac{1}{\varpi}\frac{\partial\psi}{\partial\varpi} + \frac{\partial^2\psi}{\partial z^2} = 2Cz - 2Cz + 0 = 0, \text{ and hence}$$

the general vortex equation (23) is satisfied. The last term is obtained from the centrifugal force. Thus, since $f(\psi) = v\varpi = C\varpi^2 z$, we have,

$$(37) \qquad \frac{2f(\psi)\frac{\partial f(\psi)}{\partial z}}{\varpi^2} = \frac{2C\varpi^2 z . C\varpi^2}{\varpi^2} = 2C^2\varpi z.$$

The structure of the vortex is such that the following relations hold true on the same level, as will be illustrated in the discussion of the Cottage City waterspout.

(38)	Ratio.	$\log\rho = \log\frac{\varpi_n}{\varpi_{n+1}}$	= the ratio between successive tubes.
(39)	Constant.	$\log C_n = \log C_0 + 2n\log\rho$	$= \log C_0 + 2n\log\frac{\varpi_n}{\varpi_{n+1}}$.
(40)	Radius.	$\log\varpi_n = \log\varpi_0 - n\log\rho$	$= \log\varpi_0 - n\log\frac{\varpi_n}{\varpi_{n+1}}$.
(41)	Radial.	$\log u_n = \log u_0 + n\log\rho$	$= \log u_0 + n\log\frac{\varpi_n}{\varpi_{n+1}}$.
(42)	Tangential.	$\log v_n = \log v_0 + n\log\rho$	$= \log v_0 + n\log\frac{\varpi_n}{\varpi_{n+1}}$.
(43)	Vertical.	$\log w_n = \log w_0 + 2n\log\rho$	$= \log w_0 + 2n\log\frac{\varpi_n}{\varpi_{n+1}}$.
(44)	Horizontal.	$\log\tan i_n =$ constant.	
(45)	Vertical.	$\log\tan\eta_n = \log\tan\eta_0 + n\log\rho$	$= \log\tan\eta_0 + n\log\frac{\varpi_n}{\varpi_{n+1}}$.
(46)	Time.	$\log t_n = \log t_0 - 2n\log\rho$	$= \log t_0 - 2n\log\frac{\varpi_n}{\varpi_{n+1}}$.
(47)	Volume.	$\text{Volume} = \pi\left(\varpi_n^2 - \varpi_{n+1}^2\right)w_m$	= constant.
(48)	Centrifugal.	$\log\left(\frac{v^2}{\varpi}\right)_n = \log\left(\frac{v^2}{\varpi}\right)_0 + 3n\log\rho$	$= \log\left(\frac{v^2}{\varpi}\right)_0 + 3n\log\frac{\varpi_n}{\varpi_{n+1}}$.
(49)	Pressure.	$\log\frac{B_n - B_{n+1}}{B_{n-1} - B_n} - \log\frac{\varpi_n}{\varpi_{n+1}}$	$= \log\rho = \log\frac{\varpi_n}{\varpi_{n+1}}$.

Formulas for the radial, tangential, and vertical velocities.

It will be convenient to use different coordinate axes in solving the two types of vortices represented respectively by the funnel-shaped and the dumb-bell-shaped tubes, photographed in Chamberlain 3d A and 2d A. For the former the z-axis should be taken *positive downward* from a reference plane near the base of the cumulus cloud from which the vortex is projected; for the latter the reference plane is below the surface of the sea, and the z-axis is *positive upward.* The reason for this change in the direction of the coordinates will clearly appear in the discussion of the examples of the dumb-bell vortex.

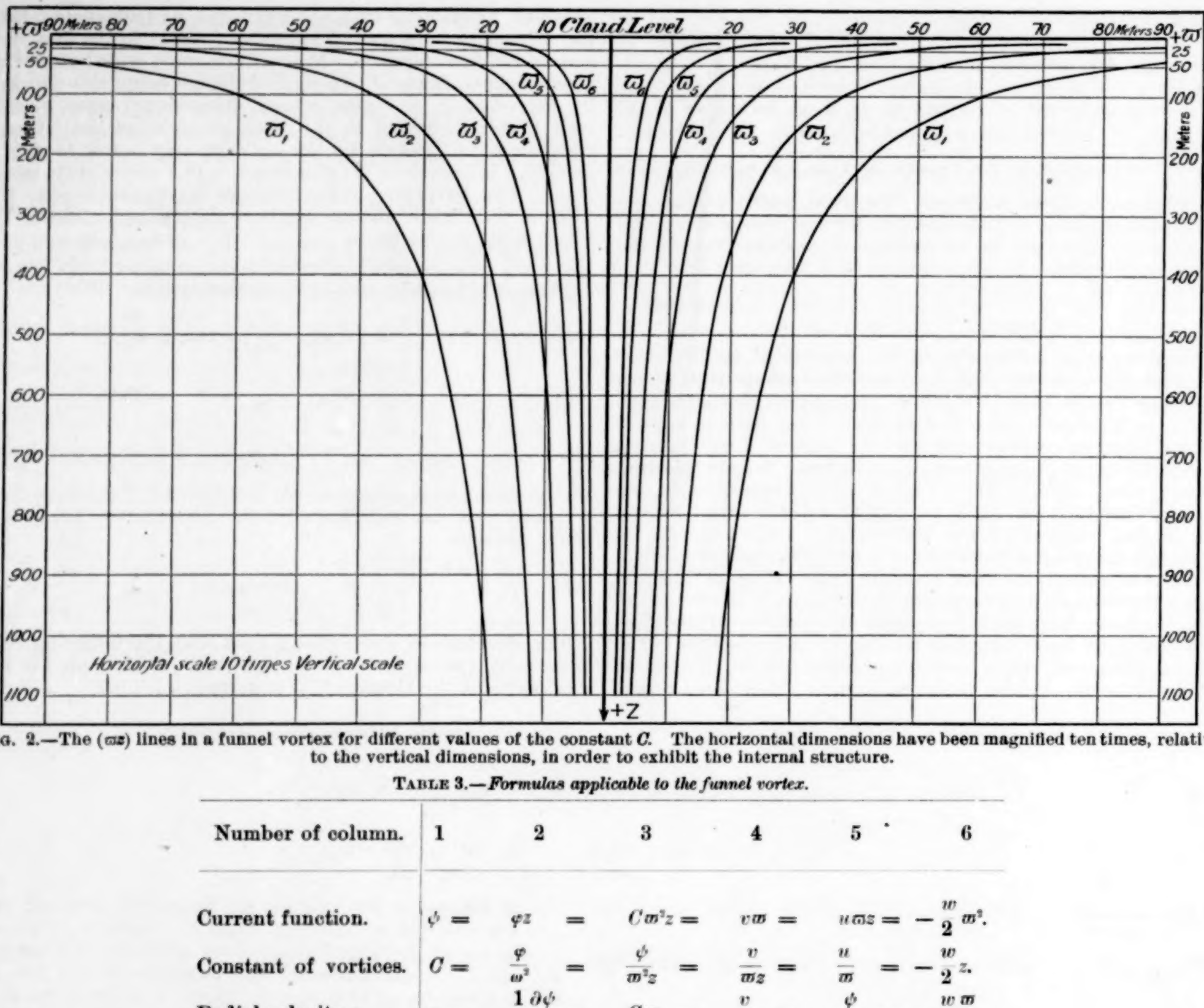

FIG. 2.—The (ϖz) lines in a funnel vortex for different values of the constant C. The horizontal dimensions have been magnified ten times, relative to the vertical dimensions, in order to exhibit the internal structure.

TABLE 3.—*Formulas applicable to the funnel vortex.*

Number of column.	1		2		3		4		5		6
Current function.	ψ	=	φz	=	$C\varpi^2 z$	=	$v\varpi$	=	$u\varpi z$	=	$-\frac{w}{2}\varpi^2.$
Constant of vortices.	C	=	$\frac{\varphi}{\varpi^2}$	=	$\frac{\psi}{\varpi^2 z}$	=	$\frac{v}{\varpi z}$	=	$\frac{u}{\varpi}$	=	$-\frac{w}{2z}.$
Radial velocity.	u	=	$\frac{1}{\varpi}\frac{\partial\psi}{\partial z}$	=	$C\varpi$	=	$\frac{v}{z}$	=	$\frac{\psi}{\varpi z}$	=	$-\frac{w}{2}\frac{\varpi}{z}.$
Tangential velocity.	v	=	$\frac{\psi}{\varpi}$	=	$C\varpi z$	=	uz	=	$\frac{\psi}{\varpi}$	=	$-\frac{w}{2}\varpi.$
Vertical velocity.	w	=	$-\frac{1}{\varpi}\frac{\partial\psi}{\partial\varpi}$	=	$-2Cz$	=	$-\frac{2uz}{\varpi}$	=	$-\frac{2\psi}{\varpi^2}$	=	$-\frac{2v}{\varpi}.$

The formulas for the radial (u), tangential (v), and vertical (w) velocities are given in Table 3, together with several check combinations.

Having adopted the form of current function, ψ, then the radial and vertical velocities are found from Stokes's functions and the tangential velocity from the vortex law, $\varphi = v\varpi =$ constant. It is evident that one value of the constant C holds true for a single stream line (ϖz), but changes its value from one vortex tube to another. Thus, for the lines in the Cottage City waterspout, we have for—

Line (1) $C_1 = 0.001111.$
Line (2) $C_2 = 0.002862.$
Line (3) $C_3 = 0.007372.$
Line (4) $C_4 = 0.018990.$
Line (5) $C_5 = 0.048910.$
Line (6) $C_6 = 0.126000.$

It was for a long while impossible to discover a method for computing these values of C_1, C_2, etc., because no velocities but only the dimensions of the outer sheath (1) were available for use. It is seen by the formulas that the dimensions of the vortex depend upon C, even when the (ϖ, z) are known, so that if the height z and the radius ϖ are given at successive points it is yet necessary to know C before the velocities can be computed even approximately. The velocities (u, v, w) all increase with C, and hence they are all greater in the interior in proportion to the approach to the axis; u increases but v and w diminish with approach to the plane of reference at the base of the cloud, as determined by the formulas in column 3.

In a vortex of this kind the simplest relation is that the ratios of the successive radii are equal and constant, so that,

$$\rho = \frac{\varpi_1}{\varpi_2} = \frac{\varpi_2}{\varpi_3} = \frac{\varpi_3}{\varpi_4} = \dots \frac{\varpi_n}{\varpi_{n+1}}$$

If the values of the radii of successive isobars can be measured, ϖ_1 (outer), ϖ_2, ϖ_3, ... ϖ_n (inner) the value of ρ can be readily computed. The approximate radii of the circular isobars in hurricanes and cyclones can be thus measured on the charts, and from these the value of ρ, and log ρ, determined as a mean. Thus for four cases, i. e., the De Witte hurricane, the St. Louis tornado, a typical large ocean cyclone, and a typical large land cyclone, I have computed log ρ from the available data. (See Table 4.)

TABLE 4.—*Values of log ρ in several vortices.*

De W. hurricane.			S. L. tornado.			Ocean cyclone.			Land cyclone.		
B	*log ρ*		*B*	*log ρ*		*B*	*log ρ*		*B*	*log ρ*	
760			755			755			760		
	0.20412			0.20412			0.10266			0.10791	
750			745			750			755		
	0.19269			0.20412			0.10914			0.12390	
740			735			745			750		
	0.21904			0.19382			0.10003	Constant 0.21000 (10 mm.)		0.15924	Variable.
730		Constant.	725		Constant.	740			745		
	0.16230			0.23408			0.10959			0.22874	
720			715			735			740		
	0.23798			0.19189			0.10400			0.43573	
710			705			730			735		
	0.22578			0.21388			0.12665				
700			695			725		Variable.			
	0.19626			0.19629			0.16428				
690			685			720					
							0.24055				
Means ...	0.20563			0.20546			0.10500				
	1.6056			1.60493			1.27350				

In the hurricane and tornado, log ρ is practically constant and nearly the same in value; in the ocean cyclone it is constant outside of the isobar 730, but increases in value toward the axis from isobar 730 to isobar 715, showing that the ocean cyclone is not a pure vortex near the center. In the land cyclone, log ρ is not constant, but enlarges in the same ratio that occurs near the center of the ocean cyclone, showing that the land cyclones do not follow the pure vortex law, even approximately.

Since the Cottage City waterspout resembles the pure vortices of the tornado and hurricane more than the imperfect vortices of the ocean and land cyclones, it is proper to adopt log $\rho = 0.20546$ as an approximate value. It may be found that some such value of log ρ is a characteristic of the earth's atmosphere, when its small vortices develop freely; that is, it may be a typical constant, while other atmospheres may operate according to a different constant.

The current function constant,

$$\log \psi = \log (v\,\varpi) = 2.60206,$$

has been determined by a series of trials, which it is not necessary here to enumerate. If it were possible to measure the tangential velocity v at any point $(\varpi_1 z)$ in the vortex, as, for instance, on the sheath, where it begins to expand rapidly before merging with the cloud, then we should have $\psi = v\,\varpi =$ constant. Several such measures at different points on the sheath $(v_1\,\varpi_1)$, $(v_2\,\varpi_2)$, etc., would give several values for the constant, and the mean could be taken as available thruout the vortex. This can be done for the tornado and the hurricane on the ground, or at the sea level; but with the waterspout it is possible only to assume certain values of v at a given height, z, measure ϖ, compute the tube from the cloud to the sea level, and by interpolation compare with the observed dimensions as taken from the photograph. It was finally determined to adopt the following initial data:

$$\text{At height } z = 100 \text{ meters.} \left\{ \begin{aligned} \varpi &= 60 \text{ meters.} \\ v &= 6.67 \text{ meters per second.} \\ \log \psi &= 2.60206 \\ \log \rho &= 0.20546 \end{aligned} \right.$$

Table 5 shows the manner in which the tube obtained from the computation to be given matches the dimensions scaled from the photograph, Chamberlain 3d A.

TABLE 5.—*Comparison of the computed and observed radii, Chamberlain 3d A, in meters.*

Height z.	Radius computed ϖ	Radius Chamberlain 3d A.*
0	∞	....
1	600.0	(600)
2	424.3	....
5	268.4	....
10	189.7	200
25	120.0	125
50	84.9	85
100	60.0	60
200	42.4	43
300	34.6	35
400	30.0	30
500	26.8	25
600	24.5	23
700	22.7	22
800	21.2	20
900	20.0	19
1000	19.0	18
1100	18.1	....

*1 millimeter on photograph = 18.3 meters at the waterspout.

There is some uncertainty in tracing the form of the vortex head near the cloud, but the darkening of the cloud in Chamberlain 3d A and 3d B indicates that the vortex spreads out to about 1200 meters in diameter, something like the height of the cloud base from the sea level. This gives 600 meters radius near the plane of reference, as in the table. At the bottom the tube is surrounded by a lofty cascade, which prevents the measurement of the radius at the level $z = 1100$ meters.

The constants C are found at first from computations with log ψ, ϖ, z on the level $z = 100$, using the measured radius ϖ_1, and applying log ρ to the log ϖ_1 by formula (30), in succession from the outer to the inner tubes, which are supposed to be separated from each other by the pressure in millimeters of mercury, as determined by (49). An example of the preliminary computation is shown in full in Table 6.

The results of Table 6, Section I, there computed for the height z=100 meters, are entered in sections I, II, III, table 7, in the appropriate line, and printed in heavier type. The other parts of these tables are to be computed from these data for all the other altitudes. Having computed the radial distance from the axis at all altitudes in order to find the *radial* component u, it is only necessary to multiply ϖ by the C of the respective lines; to find the *tangential* component it is enough to multiply u at each point by the height z; and to obtain the *vertical* component it is sufficient to multiply $-2C$ by the height z. In this vortex the component velocities and the coordinate distances stand in very simple relations, and this is probably one reason why the atmosphere tends to circulate according to this simple solution of the second equation of motion.

An inspection of Table 7, Sections I, II, III, shows that the following facts hold true in regard to the velocities. The *radial* component u increases slowly upward thru the long, tapering tube till very near the cloud base, and it then increases very rapidly; it is greater in the interior of the vortex than in the outside tubes, showing that the inner helices slope outward more rapidly than do the outer ones; it is probable that the extreme actual radial velocity in a horizontal plane near the cloud is practically about 5 meters per second where the tangential rotating velocity disappears. The *tangential* velocity decreases rapidly upward, especially in the inner tubes, and it increases rapidly from the outer tube toward the axis, where it may amount to 200 meters per second, or 447 miles per hour. It is not probable that such enormous velocities exist in the atmosphere even under vortex conditions, but a pure vortex evidently develops tremendous gyratory motions very near the axis. The *vertical* velocity decreases rapidly upward, more so as the tubes diminish their dimensions; but it increases toward the axis, where it may

attain the enormous velocity of 250 meters per second, or 559 miles per hour. In the extreme total velocity, at the point where this computation ends, if the vortex actually develops so near the axis, we have,

$$q_5 = [(0.13)^2 + (146.7)^2 + (107.6)^2]^{1/2} = 182 \text{ meters per second, or 407 miles per hour.}$$

In Table 8 are given the total velocity q at numerous points within the vortex, the horizontal angle i, which it makes in the plane at the height z, and at the point ϖ, φ with the tangent to the circle; also the vertical angle η, which it makes at the same point with the tangent. (See fig. 1.) The angle i is positive outward and the angle η is negative upward in this system of coordinates. Section I of this table shows that the angle i is the same for each tube on a given section at the height z, and it increases upward slowly thru the long, tapering tube and very rapidly in the last 10 meters, where the motion of q is becoming asymptotic to the plane of reference. The angle η decreases upward and becomes zero at the cloud base; it increases rapidly from the outer tube toward the axis, and seems to be limited by the angle 36° on tube 5. The angle of the pitch of the helix is steeper near the center of the

TABLE 6.—*Cottage City Waterspout. Chamberlain, 3d A. Computation of the radius ϖ thruout the vortex.*

Assume $\varpi = 60$ at $z = 100$; $\log \psi = 2.60206$; $\log \rho = 0.20546$.

I. Line.	(1)	(2)	(3)	(4)	(5)	(6)	Formula.
$\log \varpi$	1.77815	1.57269	1.36723	1.16177	0.95631	0.75085	
ϖ	60.0	37.4	23.3	14.5	9.0	5.6	$\varpi_{n+1} = \frac{\varpi_n}{\rho}$.
$\log \varpi^2$	3.55630	3.14538	2.73446	2.32354	1.91262	1.50170	
z	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	
$\varpi^2 z$	5.55630	5.14538	4.73446	4.32354	3.91262	3.50170	
$\log C$	7.04576	7.45668	7.86760	8.27852	8.68944	9.10036	
C	0.001111	0.002862	0.007372	0.01899	0.04891	0.12600	$C = \frac{\psi}{\varpi^2 z}$.
$\log C\varpi$	8.82391	9.02937	9.23483	9.44029	9.64575	9.85121	
u	0.06667	0.1070	0.1717	0.2756	0.4423	0.7099	$u = C\varpi$.
$\log \frac{\psi}{\varpi}$	0.82391	1.02937	1.23483	1.44029	1.64575	1.85121	
v	6.67	10.70	17.17	27.56	44.23	70.99	$v = \frac{\psi}{\varpi}$.
$-\log 2Cz$	−9.34679	−9.75771	−0.16863	−0.57955	−0.99047	−1.40139	
w	−0.222	−0.572	−1.474	−3.798	−9.783	−25.199	$w = -2Cz$.

These data can be used to test the other formulas given in Table 3. In computing from the 100-meter level to other values of (ϖz), we proceed as follows, showing as examples a few of the levels only for $C_1 = 0.00111$; $\varpi^2 = \frac{\psi}{C_1 z}$:

Radius ϖ in all parts of the vortex.

II. z	$\log z$	$\log C_1 z$	$\log \varpi^2$	$\log \varpi_1$	$\log \varpi_2$	$\log \varpi$	$\log \varpi_4$	$\log \varpi_5$	$\log \varpi_6$
0	$-\infty$	$-\infty$	∞	∞	∞	∞	∞	∞	∞
10	1.00000	8.04576	4.55630	2.27815	2.07269	1.86723	1.66177	1.45631	1.25085
100	2.00000	9.04576	3.55630	**1.77815**	**1.57269**	**1.36723**	**1.16177**	**0.95631**	**0.75085**
200	2.30103	9.34679	3.25527	1.62764	1.42218	1.21672	1.01126	0.80580	0.60034
300	2.47712	9.52288	3.07918	1.53959	1.33413	1.12867	0.92321	0.71775	0.51229
700	2.84510	9.89086	2.71120	1.35560	1.15014	0.94468	0.73922	0.53376	0.32830
1100	3.04139	0.08715	2.51491	1.25746	1.05200	0.84654	0.64108	0.43562	0.23016

III. z				ϖ_1	ϖ_2	ϖ_3	ϖ_4	ϖ_5	ϖ_6
0				∞	∞	∞	∞	∞	∞
1				600.0	373.8	232.9	145.1	90.4	56.3
2				424.3	264.4	164.7	102.6	63.9	39.8
5				268.4	167.2	104.2	64.9	40.4	25.2
10				189.7	118.2	73.7	45.9	28.6	17.8
25	These computations need not be			120.0	74.8	46.6	29.0	18.1	11.3
50	executed.			84.9	52.9	32.9	20.5	12.8	8.0
100				60.0	37.4	23.3	14.5	9.0	5.6
200				42.4	26.4	16.5	10.3	6.4	4.0
300				34.6	21.6	13.5	8.4	5.2	3.3
400				30.0	18.7	11.7	7.3	4.5	2.8
500				26.8	16.7	10.4	6.5	4.0	2.5
600				24.5	15.2	9.5	5.9	3.7	2.3
700				22.7	14.1	8.8	5.5	3.4	2.1
800				21.2	13.2	8.2	5.1	3.2	2.0
900				20.0	12.5	7.8	4.8	3.0	1.9
1000				19.0	11.8	7.4	4.6	2.9	1.8
1100				18.1	11.3	7.0	4.4	2.7	1.7

For the other values of C_n following $C_1 = 0.001111$ it is sufficient to subtract $\log \rho = 0.20546$ from the values of $\log \varpi_1$ under C_1 in succession to one another in Section II. The $\log \varpi$ of Section I appears in its place in Section II.

vortex at the sea level than at any other point, the pitch diminishing upward and outward. The total velocity q is greatest near the axis at sea level, it diminishes rapidly outward and upward, and its magnitude near the axis is astonishing.

The time of the rotation of a particle on a given plane is found as follows. The length of the path is $2\pi\varpi$, the velocity v; so that $t = \frac{2\pi\varpi}{v}$. Take as an example the plane $z = 1100$. (See Table 9.)

It takes 5.14 seconds to make one circuit about the axis at the surface of the ocean on the outer tube, and 0.04 second, i. e., one twenty-fifth of a second, on the sixth or inner tube. Subtracting the successive values of $\log t$, $(\log t_1 - \log t_2)\ldots$, the result is $2 \log \rho$ in all cases, so that the time of rotation in the different parts of the vortex can be computed from a few initial values. In this way it is seen that even a few isolated observations of the radius ϖ and velocity v can be used to construct the entire vortex. A single anemometer record in a vortex at a distance ϖ from the center of the track is therefore of great value in theoretical meteorological discussions. A consideration of the forces of pressure involved in these velocities is sufficient to see where the powerful destructive forces arise, whose effects are noted in the débris which mark the track of even a small funnel-shaped tornado tube.

TABLE 7.—*Computation of the radial, tangential, and vertical velocities thruout the vortex.*

I. THE RADIAL COMPONENT, $u=C\varpi$.

z	(1) $\log u_1$	(2) $\log u_2$	(3) $\log u_3$	(4) $\log u_4$	(5) $\log u_5$	(6) $\log u_6$
0	∞	∞	∞	∞	∞	∞
10	9.32491	9.53037	9.73583	9.94129	0.14675	0.35221
100	**8.82391**	**9.02937**	**9.23483**	**9.44029**	**9.64575**	**9.85121**
200	8.67340	8.87886	9.08432	9.28978	9.49524	9.70070
300	8.58535	8.79081	8.99627	9.20173	9.40719	9.61265
700	8.40136	8.60682	8.81228	9.01774	9.22320	9.42866
1100	8.30322	8.50868	8.71414	8.91960	9.12506	9.33052

z	u_1	u_2	u_3	u_4	u_5	u_6
0	∞	∞	∞	∞	∞	∞
1	0.667	1.070	1.717	2.756	4.423	7.099
2	0.471	0.757	1.214	1.949	3.128	5.020
5	0.298	0.479	0.768	1.233	1.978	3.175
10	0.211	0.339	0.544	0.874	1.402	2.250
25	0.133	0.214	0.343	0.551	0.885	1.420
50	0.094	0.151	0.243	0.390	0.626	1.004
100	**0.067**	**0.107**	**0.172**	**0.276**	**0.442**	**0.710**
200	0.047	0.076	0.121	0.195	0.313	0.502
300	0.039	0.062	0.099	0.159	0.255	0.410
400	0.033	0.054	0.086	0.138	0.221	0.355
500	0.030	0.048	0.077	0.123	0.198	0.318
600	0.027	0.044	0.070	0.113	0.180	0.290
700	0.025	0.040	0.065	0.104	0.167	0.268
800	0.023	0.038	0.061	0.097	0.156	0.251
900	0.022	0.036	0.057	0.092	0.147	0.237
1000	0.021	0.034	0.054	0.087	0.140	0.225
1100	0.020	0.032	0.052	0.083	0.133	0.214

II. THE TANGENTIAL COMPONENT, $v=C\varpi z$.

z	(1) $\log v_1$	(2) $\log v_2$	(3) $\log v_3$	(4) $\log v_4$	(5) $\log v_5$	(6) $\log v_6$
0	−∞	−∞	−∞	−∞	−∞	−∞
10	0.32391	0.52937	0.73483	0.94029	1.14575	1.35121
100	**0.82391**	**1.02937**	**1.23483**	**1.44029**	**1.64575**	**1.85121**
200	0.97442	1.17988	1.38534	1.59080	1.79626	2.00172
300	1.06247	1.26793	1.47339	1.67885	1.88431	2.08977
700	1.24646	1.45192	1.65738	1.86284	2.06830	2.27376
1100	1.34460	1.55006	1.75552	1.96098	2.16644	2.37190

z	v_1	v_2	v_3	v_4	v_5	v_6
0	0	0	0	0	0	0
1	0.7	1.1	1.7	2.8	4.4	7.1
2	0.9	1.5	2.4	3.9	6.3	10.0
5	1.5	2.4	3.8	6.2	9.9	15.9
10	2.1	3.4	5.4	8.7	14.0	22.5
25	3.3	5.4	8.6	13.8	22.1	35.5
50	4.7	7.6	12.1	19.5	31.3	50.2
100	**6.7**	**10.7**	**17.2**	**27.6**	**44.2**	**71.0**
200	9.4	15.1	24.3	39.0	62.6	100.4
300	11.6	18.5	29.7	47.7	76.6	122.9
400	13.3	21.4	34.3	55.1	88.5	142.0
500	14.9	23.9	38.4	61.6	98.9	158.7
600	16.3	26.2	42.1	67.5	108.3	173.9
700	17.6	28.3	45.4	72.9	117.0	187.8
800	18.9	30.3	48.6	78.0	125.1	200.8
900	20.0	32.1	51.5	82.7	132.7	213.0
1000	21.1	33.8	54.3	87.2	139.9	224.5
1100	22.1	35.5	57.0	91.4	146.7	235.4

TABLE 7—*Continued.* III. THE VERTICAL COMPONENT, $w=-2Cz$.

z	(1) $\log w_1$	(2) $\log w_2$	(3) $\log w_3$	(4) $\log w_4$	(5) $\log w_5$	(6) $\log w_6$
0	−∞	−∞	−∞	−∞	−∞	−∞
10	8.34679	8.75771	9.16863	9.57955	9.99047	0.40139
100	**9.34679**	**9.75771**	**0.16863**	**0.57955**	**0.99047**	**1.40139**
200	9.64782	0.05874	0.46966	0.88058	1.29150	1.70242
300	9.82391	0.23483	0.64575	1.05667	1.46759	1.87851
700	0.19189	0.60281	1.01373	1.42465	1.83557	2.24649
1100	0.38818	0.79910	1.21002	1.62094	2.03186	2.44278

z	w_1	w_2	w_3	w_4	w_5	w_6
0	0	0	0	0	0	0
1	−0.0022	−0.0057	−0.0147	−0.0380	−0.0978	−0.2520
2	−0.0044	−0.0115	−0.0295	−0.0760	−0.1957	−0.5040
5	−0.0111	−0.0286	−0.0737	−0.1899	−0.4891	−1.260
10	−0.0222	−0.0572	−0.1474	−0.3798	−0.9783	−2.520
25	−0.0556	−0.1431	−0.3686	−0.9495	−2.446	−6.300
50	−0.1110	−0.2862	−0.7372	−1.899	−4.891	−12.60
100	**−0.222**	**−0.572**	**−1.474**	**−3.798**	**−9.783**	**−25.20**
200	−0.444	−1.145	2.949	−7.596	−19.57	−50.40
300	−0.667	−1.717	.. 4.423	−11.39	−29.35	−75.60
400	−0.889	−2.290	−5.898	−15.19	−39.13	−100.80
500	−1.111	−2.862	−7.372	−18.99	−48.91	−126.00
600	−1.333	−3.434	−8.847	−22.79	−58.70	−151.20
700	−1.556	−4.007	−10.32	−26.59	−68.48	−176.40
800	−1.778	−4.579	−11.79	−30.38	−78.26	−201.60
900	−2.000	−5.152	−13.27	−34.18	−88.05	−226.80
1000	−2.222	−5.724	−14.74	−37.98	−97.83	−252.00
1100	−2.444	−6.297	−16.22	−41.78	−107.61	−277.20

NOTE.—This vortex probably does not develop beyond ϖ_5, u_5 v_5 w_5.

TABLE 8.—*The angles (i, η) which the current having the velocity of q makes with the tangent at (ϖ, ϕ). (Fig. 1.*)*

I.—HORIZONTAL ANGLE i $\left(\tan i = \frac{u}{v}\right)$.

z	(1)	(2)	(3)	(4)	(5)	(6)
0	∞	∞	∞	∞	∞	∞
10	9.00100	9.00100	9.00100	9.00100	9.00100	9.00100
50	8.30104	8.30104	8.30104	8.30104	8.30104	8.30104
100	8.00000	8.00000	8.00000	8.00000	8.00000	8.00000
300	7.52288	7.52288	7.52288	7.52288	7.52288	7.52288
500	7.30104	7.30104	7.30104	7.30104	7.30104	7.30104
700	7.15490	7.15490	7.15490	7.15490	7.15490	7.15490
900	7.04576	7.04576	7.04576	7.04576	7.04576	7.04576
1100	6.95862	6.95862	6.95862	6.95862	6.95862	6.95862

z	(1)	(2)	(3)	(4)	(5)	(6)
	° ′	° ′	° ′	° ′	° ′	° ′
0	90 0	90 0	90 0	90 0	90 0	90 0
10	5 43	5 43	5 43	5 43	5 43	5 43
50	1 9	1 9	1 9	1 9	1 9	1 9
100	0 34	0 34	0 34	0 34	0 34	0 34
300	0 11	0 11	0 11	0 11	0 11	0 11
500	0 7	0 7	0 7	0 7	0 7	0 7
700	0 5	0 5	0 5	0 5	0 5	0 5
900	0 4	0 4	0 4	0 4	0 4	0 4
1100	0 3	0 3	0 3	0 3	0 3	0 3

II.—VERTICAL ANGLE η $\left(-\tan \eta = \frac{w}{v \sec i}\right)$.

z	(1)	(2)	(3)	(4)	(5)	(6)
0	∞	∞	∞	∞	∞	∞
10	8.02071	8.22617	8.43163	8.63709	8.84255	9.04801
50	8.37237	8.57783	8.78329	8.98875	9.19421	9.39967
100	8.52288	8.72834	8.93380	9.13926	9.34472	9.55018
300	8.76144	8.96690	9.17236	9.37782	9.58328	9.78874
500	8.87237	9.07783	9.28329	9.48875	9.69421	9.89967
700	8.94543	9.15089	9.35635	9.56181	9.76727	9.97273
900	9.00000	9.20546	9.41092	9.61638	9.82184	0.02730
1100	9.04358	9.24904	9.45450	9.65996	9.86542	0.07088

z	(1)	(2)	(3)	(4)	(5)	(6)
	° ′	° ′	° ′	° ′	° ′	° ′
0	0 0	0 0	0 0	0 0	0 0	0 0
10	0 36	0 58	1 33	2 29	3 59	6 22
50	1 18	2 10	3 28	5 34	8 53	14 5
100	1 55	3 4	4 54	7 51	12 28	19 33
300	3 18	5 18	8 28	13 25	20 58	31 35
500	4 16	6 49	10 52	17 8	26 19	38 26
700	5 2	8 3	12 48	20 2	30 20	43 12
900	5 43	9 7	14 27	22 28	33 34	46 48
1100	6 19	10 4	15 54	24 34	36 16	49 39

TABLE 8—*Continued.*

III.—TOTAL VELOCITY, $q=(u^2+v^2+w^2)^{\frac{1}{2}}$.

z	(1)	(2)	(3)	(4)	(5)	(6)
0	0.00	0.00	0.00	0.00	0.00	0.00
10	2.12	3.40	5.46	8.77	14.09	22.73
50	4.72	7.57	12.15	19.50	31.30	51.77
100	6.67	10.71	17.18	27.58	44.26	75.34
300	11.6	18.6	30.1	49.1	80.2	144.3
500	14.9	24.1	39.1	64.4	110.3	202.7
700	17.7	28.6	46.6	77.6	135.6	257.7
900	20.1	32.5	53.2	89.4	159.2	311.2
1100	22.3	36.0	59.2	100.5	182.0	363.7

*The vector (q, i, η) makes the angle i on the horizontal plane with the tangent at the point (ϖ, ϕ) and the angle η in the vertical plane at the same point. The sec. i can be neglected except very near the cloud level where the angle i increases rapidly to 90°.

TABLE 9.—*Time to make one circuit at different distances* ϖ.

$z=1100$	(1)	(2)	(3)	(4)	(5)	(6)
log ϖ	1.25746	1.05200	0.84654	0.64108	0.43562	0.23016
log 2π	0.79818					
log $2\pi\varpi$	2.05564	1.85018	1.64472	1.43926	1.23380	1.02834
log v	1.34460	1.55006	1.75552	1.96098	2.16644	2.37190
log t	0.71104	0.30012	9.88920	9.47828	9.06736	8.65644
t	5.14	2.00	0.77	0.30	0.12	0.04

The volume of air transferred upward thru each horizontal section, in the areas bounded by the circles $\varpi_1, \varpi_2, \varpi_3, \varpi_4, \varpi_5, \varpi_6$, at a given elevation, is the same on a given level, and it is also the same thru every horizontal plane. In other words, the volume of air flowing upward is the same in every cylindrical ring-area bounded by the surfaces generated thru the revolution of the lines (ϖ, z) around the central axis. This is easily computed by the formula,

$$\text{volume, } V=\pi\,(\varpi_n^2-\varpi_{n+1}^2)\,w_m,$$

where w_m is the mean vertical velocity on a given ring section. Two examples are taken on the sections for $z=100$, and $z=1100$ meters. Take log ϖ from Table 6, Section II, and log w from Table 7, Section III.

TABLE 10.—*Volume* $=\pi\,(\varpi_n^2-\varpi_{n+1}^2)\,w_m$.

$z=100$	(1)		(2)		(3)		(4)		(5)		(6)	
log ϖ	1.77815		1.57269		1.36723		1.16177		0.95631		0.75085	Table 6, II.
log ϖ^2	3.55630		3.14538		2.73446		2.32354		1.91262		1.50170	
ϖ^2	3600.0		1397.60		542.58		210.64		81.775		31.747	
$\varpi_n^2-\varpi_{n+1}^2$		2202.4		855.02		331.94		128.865		50.028		
log		3.34290		2.93198		2.52106		2.11014		1.69922		
log w	9.34679		9.75771		0.16863		0.57955		0.99047		1.40139	Table 7, III.
log w_m		9.55225		9.96317		0.37409		0.78501		1.19593		
log π		0.49715		0.49715		0.49715		0.49715		0.49715		
log V		3.39230		3.39230		3.39230		3.39230		3.39230		
Volume		2467.7		2467.7		2467.7		2467.7		2467.7		
$z=1100$	(1)		(2)		(3)		(4)		(5)		(6)	
log ϖ	1.25746		1.05200		0.84654		0.64108		0.43562		0.23016	
$\varpi_n^2-\varpi_{n+1}^2$		200.24		77.734		30.176		11.7157		4.5482		
log		2.30155		1.89061		1.47966		1.06877		0.65784		
log w_m		0.59364		1.00456		1.41548		1.82640		2.23732		
Volume		2468.0		2467.8		2467.6		2467.8		2467.8		

Since log w plots on a straight line, the mean vertical velocity for a given area between ϖ_n and ϖ_{n+1} is found by taking log $w_m=\frac{1}{2}$ (log w_n+ log w_{n+1}). It is seen that the air is ascending in the vortex at a rate of 2467.7 cubic meters per second thru each of the vortex tube rings.

THE PRESSURES IN THE VORTEX.

It is inferred, by comparing the general equations of motion, 6 and 8, that the pressure changes can be determined as follows: On any given section at the level z the third equation need not be considered, because there is no integration in a vertical direction, dz, and the second equation can be omitted, since $-\frac{1}{\rho}\frac{\partial P}{\varpi\partial\varphi}=0$, so that there remains only the first equation. The partial differentials $u\frac{\partial u}{\partial\varpi}+w\frac{\partial u}{\partial z}$ can be neglected in this vortex where the radial velocity changes slowly, except very near the cloud base; $\frac{\partial u}{\partial t}=0$ in steady motion, and $ku=0$, practically, so that there remains for computation only,

$$-\frac{1}{\rho}\frac{\partial P}{\partial\varpi}=-\frac{v^2}{\varpi}-2n\cos\theta\,.\,v\,,$$

that is, the centrifugal and the deflecting force.

This computation is summarized in Table 11, Section I, which contains the log $\frac{v^2}{\varpi}$, and $\frac{v^2}{\varpi}$, derived from Table 7, Section II, and Table 6, Section II, the centrifugal force being exprest in mechanical units. Since the largest value of $2n\cos\theta\,.\,v=0.0227$, this term can be neglected.

In integrating for the pressure, we have,

$$P_n-P_{n+1}=\rho_m\left(\frac{v^2}{\varpi}\right)_m(\varpi_n-\varpi_{n+1}).$$

The difference of pressure between successive rings ϖ_n, ϖ_{n+1} is equal to the mean density of the air at the elevation of the horizontal section z, multiplied by the mean centrifugal force from one ring to the other, multiplied by the distance from one ring to the other. Since the air density is not really known across the section, I can only take the mean density at the elevation z, tho it is not entirely correct and evidently too large. The mean centrifugal force $\left(\frac{v^2}{\varpi}\right)_m$ is easily found. Table 11, Section I, shows that on the same level the difference of the logs of the $\frac{v^2}{\varpi}$ is $+\,3\log\rho=3\times0.20546=0.61638$. The successive values of these logs plot on a straight line so that the mean $\left(\frac{v^2}{\varpi}\right)_m$ between the rings ϖ_n and ϖ_{n+1} equals the mean of the logarithms. These values are given in Section II, together with the log ρ, which has been taken as log ρ_m.

TABLE 11.—*Computation of the pressure* B_n-B_{n+1} *thru equation C. R.* 165_1, *or* 8_1.

I.—CENTRIFUGAL FORCE $\frac{v^2}{\varpi}$.

z	(1)	(2)	(3)	(4)	(5)	(6)
0	....	....	....	....	....	....
10	8.36967	8.98605	9.60243	0.21881	0.83519	1.45157
50	9.41811	0.03449	9.65087	1.26725	1.88363	2.50001
100	9.86967	0.48605	1.10243	1.71881	2.33519	2.95157
300	0.58535	1.20173	1.81811	2.43449	3.05087	3.66725
500	0.91811	1.53449	2.15087	2.76725	3.38363	4.00001
700	1.13732	1.75370	2.37008	2.98646	3.60284	4.21922
900	1.30103	1.91741	2.53379	3.15017	3.76655	4.38293
1100	1.43174	2.04812	2.66450	3.28088	3.89726	4.51364
0	....	....	....	....	....	....
10	0.023	0.097	0.400	1.66	6.84	28.3
50	0.262	1.083	4.476	18.50	76.49	316.2
100	0.741	3.062	12.660	52.34	216.37	894.5
300	3.849	15.918	65.783	271.95	1124.3	4647.8
500	8.181	34.237	141.54	585.13	2419.0	10000.
700	13.719	56.715	234.47	969.30	4007.2	16566.
900	20.000	82.682	341.82	1413.10	5841.9	24151.
1100	27.023	111.720	461.85	1909.30	7893.3	32632.

$2\,n\cos\theta\,.\,v$ can be neglected. For [1100, (6)] $2\,n\cos\theta\,v=0.0227$.

TABLE 11.—Continued.

II.—LOG OF THE MEAN $\left(\frac{v^2}{\varpi}\right)_m$.

z	(1)-(2)	(2)-(3)	(3)-(4)	(4)-(5)	(5)-(6)	log ρ_m
0	....	....	....	....	....	0.04827
10	8.67786	9.29424	9.91062	0.52700	1.14338	0.04877
50	9.72630	0.34268	0.95906	1.57544	2.19182	0.05077
100	0.17786	0.79424	1.41062	2.02700	2.64338	0.05326
300	0.89354	1.50992	2.12630	2.74268	3.35906	0.06324
500	1.22630	1.84268	2.45906	3.07544	3.69182	0.07322
700	1.44551	2.06189	2.67827	3.29465	3.91103	0.08320
900	1.60922	2.22560	2.84198	3.45836	4.07474	0.09319
1100	1.73993	2.35631	2.97269	3.58907	4.20545	0.10318

III.—PRESSURE $P_n - P_{n+1} = \rho_m \left(\frac{v^2}{\varpi}\right)_m (\varpi_n - \varpi_{n+1})$.

z	(1)-(2)	(2)-(3)	(3)-(4)	(4)-(5)	(5)-(6)
0	....	....	....	....	....
10	3.81	9.8	25.3	65.1	167.8
50	19.14	49.3	127.0	327.1	842.7
100	38.51	99.2	255.5	658.1	1695.2
300	118.2	304.5	784.2	2020.1	5203.6
500	201.6	519.2	1337.4	3445.1	8874.0
700	288.8	743.9	1916.1	4935.4	12713.0
900	379.9	978.6	2520.7	6492.7	16724.0
1100	475.1	1233.9	3152.6	8102.6	20918.0

IV.—PRESSURE $B_n - B_{n+1} = (P_n - P_{n+1}) \times 0.0075$ (in mm).

z	(1)-(2)	(2)-(3)	(3)-(4)	(4)-(5)	(5)-(6)
0	....	....	....	....	....
10	0.029	0.07	0.2	0.5	1.3
50	0.144	0.37	1.0	2.5	6.3
100	0.289	0.74	1.9	4.9	12.7
300	0.887	2.28	5.9	15.2	39.0
500	1.512	3.89	10.1	25.8	66.6
700	2.166	5.58	14.4	37.0	95.4
900	2.849	7.34	18.9	48.7	125.4
1100	3.564	9.18	23.7	60.9	156.9

The resulting difference of pressure between successive rings, at each successive elevation, is given in Section III, and the corresponding pressure differences in millimeters of mercury in Section IV. Hence, on the level $z = 1100$ meters, near the surface of the water, we have,

ϖ_6	1.7	ϖ_5	**2.7**	ϖ_4	4.4	ϖ_3	7.0	ϖ_2	11.3	ϖ_1	**18.1**
B_6	509.0	B_5	**665.9**	B_4	726.8	B_3	750 5	B_2	759 7	B_1	**763.3**

so that the difference of pressure between ring ϖ_5 and ring ϖ_1 is equal to *97.4* mm. = *3.835* inches of mercury. By the thermodynamic computations on the waterspout summarized in Table 51, MONTHLY WEATHER REVIEW, August, 1906, it was found that the difference of pressure between the cloud base and the sea level is *91.3* mm. = *3.595* inches of mercury. It is not too much to suppose that this difference, $97.4 - 91.3 = 6.1$ mm., is due to two causes, (1) an imperfection in the value of the density $\log \rho_m = 0.10318$, which should probably be taken less in the interior of the vortex than on the outside; and (2) the fact that the inner ring of the vortex which actually develops in nature may not exactly coincide with $\varpi_5 = 2.7$. That is, the central calm may not be exactly 5.4 meters in diameter. Indeed, the solution of the equations for Bessel's functions,

$$\frac{\partial^2 \varphi}{\partial \varpi^2} - \frac{1}{\varpi}\frac{\partial \varphi}{\partial \varpi} + a^2 \varphi = 0\,,$$

which can be derived from the vortex equation,

$$\frac{\partial^2 \psi}{\partial \varpi^2} - \frac{1}{\varpi}\frac{\partial \psi}{\partial \varpi} + \frac{\partial^2 \psi}{\partial z^2} = 2\,\varpi\,\omega_z\,,$$

results in a root, $a\,\varpi_0 = 3.832$. It is probable that $a = 1$, and it has been taken as unity in the formulas for this waterspout, so that $\varpi_0 = 3.832$, which is the radius of the closest vortex tube to the axis. My computation carried the development to $\varpi_6 = 1.70$ meters, but it should probably stop short of $\varpi_5 = 2.7$, tho at what point it is not possible to decide. *We may conclude that the innermost pressure of the vortex at the sea level is about equal to that at the cloud level from whence the vortex was projected.* This view can be strengthened by the following consideration. In a pure vortex of this type the rotating velocity next to the calm core at any level is apparently equal to that of a body falling freely from the plane of reference thru the distance z, so that $v^2 = 2\,gz$.

TABLE 12.—*Comparison of* $\mathbf{v}_5$ *with* v *and* q.

Comparison of $v = \sqrt{2\,gz}$ with v_5 in Table 7, Section II.				
z	log $2gz$	log v	v	v_5
0			0.0	0.0
10	2.29252	1.14626	14.0	14.0
50	2.99149	1.49575	31.3	31.3
100	3.29252	1.64626	44.3	44.2
300	3.76964	1.88482	76.7	76.6
500	3.99149	1.99575	99.0	98.9
700	4.13762	2.06881	117.2	117.0
900	4.24676	2.12338	132.9	132.7
1100	4.33391	2.16696	146.9	146.7

Comparison of v_5 with $q = 23.06\sqrt{T.\Delta B/B}$.

From formula 13, page 470, Monthly Weather Review, October, 1906:

$$q = 23.06\sqrt{\frac{T}{B}\,\Delta B}.$$

For $\begin{cases} T = 292.7^\circ, \text{ Table 51.} \\ \Delta B = 97.4^{mm}, 763.3 - 665.9 = B_1 - B_5. \\ B = 763\ 3^{mm}, \text{ Table 51.} \end{cases}$

$v_5 = q = 141.0$ meters per second.

The close agreement between the value of the falling velocity, $v = \sqrt{2gz}$, and v_5, the velocity on the edge of the core, as given in Table 7, Section II, seems to indicate that this is a possible way in which to begin the discussion of such vortices in the atmosphere, or at least to check the results, as in this instance.

By plotting the points in a curve indicated by the coordinates $(\varpi, B_n - B_{n+1})$, as given in Table 6, II, for the radial distance ϖ, and in Table 11, IV, for the differences of the pressure between successive rings, it is found that they form a logarithmic curve, and consequently the logarithms of these coordinates plot on a straight line. The computation shows that

$$\log \frac{(B_n - B_{n+1})}{(B_{n-1} - B_n)} = 2 \log \rho \quad = 2 \times 0.20546 = 0.41092,$$

$$\log \frac{\varpi_n}{\varpi_{n+1}} = \log \rho \quad = \quad = 0.20546,$$

$$\text{Hence,} \quad \log \frac{(B_n - B_{n+1})}{(B_{n-1} - B_n)} - \log \frac{\varpi_n}{\varpi_{n+1}} = \log \rho \quad = 0.20546,$$

so that the logarithmic relation between the spaces within the successive vortex tubes and the corresponding pressures is thus determined. This value of $\log \rho = \log \frac{\varpi_n}{\varpi_{n+1}} = 0.20546$ is fundamental to the structure of a vortex, and it seems to be an atmospheric constant which should be carefully determined.

RELATION OF THE TEMPERATURE TO THE VORTEX MOTION.

The thermodynamic energy which generated this waterspout may be attributed to two principal sources. The first is the vertical rise of the lower strata induced by the general cloud motion and due to the overflowing cold stratification. The cloud generally rises in the central portions and falls on the edges, and this upward buoyancy is converted from a broad surface at the cloud base into a narrow vortex tube, *wherein the cloud surface descends in a small area to the sea level.* The second source of energy is the horizontal pressure flow of two strata of different temperatures, so that the pressure shall remain the same on each side of the surface of discontinuity. This subject will be taken up at length in the later papers of the series, but it may be noted here that the following relation holds:

$$\text{First stratum:} \quad -\int \frac{dP_1}{\rho_1} = \tfrac{1}{2}\,(v_1^2 - v_0^2) + g\,(z_1 - z_0).$$

$$\text{Second stratum:} \quad -\int \frac{dP_2}{\rho_2} = \tfrac{1}{2}\,(v_2^2 - v_0^2) + g\,(z_2 - z_0).$$

In order that on the same boundary, where $z_1 = z_2$, the pressure shall be the same, $P_1 = P_2$, after subtracting there will remain,

$$\rho_1 \tfrac{1}{2} (v_1^2 - v_0^2) = \rho_2 \tfrac{1}{2} (v_2^2 - v_0^2).$$

From the general law,

$$P_1 = \rho_1 RT_1.$$
$$P_2 = \rho_2 RT_2.$$

For $P_1 = P_2$, $\rho_1 = \frac{\rho_2 T_2}{T_1}$. Substituting,

$$\rho_2 \frac{T_2}{T_1} (v_1^2 - v_0^2) = \rho_2 (v_2^2 - v_0^2). \quad \text{Hence,}$$

$$T_2 (v_1^2 - v_0^2) = T_1 (v_2^2 - v_0^2).$$

The relative velocity of one stratum, $(v_1^2 - v_0^2)$, multiplied by the temperature of the second, T_2, equals the relative velocity of the second stratum, $(v_2^2 - v_0^2)$, multiplied by the temperature of the first, T_1; and this maintains the pressure as if the air had no motion, and the temperature gradients remained normal. The first type of vortex with the funnel-shaped tube depends upon the first principle more than upon the second, while the second type of vortex with the dumb-bell tube depends upon the second rather than upon the first. This will be illustrated by the Chamberlain 2d A, the St. Louis tornado, and the De Witte hurricane. The ocean cyclone has in addition to these two sources of motion a third, similar to the last, but modified by the fact that the boundary of the stratification between the cold and warm masses instead of being horizontal is vertical in part, as shown by the temperature distributions in cyclones and anticyclones up to 10,000 meters. The land cyclones depend more decidedly upon the third source of motion than does the ocean cyclone.

II.—THE THEORY OF VORTEX MOTION APPLICABLE TO THE DUMB-BELL-SHAPED TUBE IN THE COTTAGE CITY WATERSPOUT.

THE DUMB-BELL-SHAPED TYPE, COTTAGE CITY WATERSPOUT, CHAMBERLAIN 2D A.

An examination of the photographs of the Cottage City waterspout given in the MONTHLY WEATHER REVIEW for July, 1906, pp. 307–315 and Plates I–X, shows that two distinct forms of the tube or types of the vortex were developed at different times from the same cloud. At the second appearance, 1:02 p. m. to 1:17 p. m. (Plates I–VII), the dumb-bell-shaped type prevailed (see Chamberlain's photograph 2d A); and at the third appearance, 1:20 p. m. to 1:27 p. m. (Plates VIII–X.), the funnel-shaped type was exhibited. In all accessible photographs of tornadoes these two types occur quite indifferently in numbers, apparently developed by subtle differences in the physical conditions of the cloud at the several occasions of their formation. While both types are of theoretical interest, it is much more important for the meteorologist to understand the dumb-bell type, because the large tornadoes, the hurricanes, and the cyclones in part, are constructed upon the same principles, differing from one another only in their dimensions and proportions. Since the ultimate explanation of the motions of the atmosphere in cyclones and anticyclones seems to be very closely associated with the theory of dumb-bell vortices, it will be proper to keep in mind the goal toward which this present exposition tends.

It can easily be seen in the photographs above referred to, 2d A to 2d G, inclusive (Plates I to VII), that the tube, instead of continuing to taper from the cloud to the sea level, reaches a minimum diameter more than halfway down from the cloud to the sea and then begins to expand. The lower portion is not entirely visible, on account of the enveloping cascade of spray, and it will be shown in these papers that, in fact, the lowest section is not fully developed, and that the vortex tube is amputated or truncated by the sea-level surface at from one-twentieth to one-third of its theoretical length, according to circumstances. The corresponding upper section is fully developed at the cloud, tho the tube and the cloud merge into one another before the asymptotic extension of the vortex is reached. When the tube begins to break up, and the gyratory velocity diminishes, the dumb-bell form appears more clearly, as on 2d F, and it is very distinct on 2d G. In the earlier numbers of the series, 2d A to 2d E, the inner tubes of the complete vortex, which have very great velocities, are formed, but the outer tubes appear as the rotation velocity falls in amount.

According to the formulas of the first paper of this series (compare Table 3 and Cloud Report, 1898, page 513), we begin with the vortex system exprest as follows:

1. Current function. $\psi = \frac{v\varpi}{a} = A\varpi^2 \sin az.$

2. Radial velocity. $u = -\frac{1}{\varpi}\frac{\partial\psi}{\partial z} = -Aa\varpi \cos az.$

3. Tangential velocity. $v = \frac{a\psi}{\varpi} = Aa\varpi \sin az.$

4. Vertical velocity. $w = \frac{1}{\varpi}\frac{\partial\psi}{\partial\varpi} = 2A \sin az.$

APPLICATION OF THE FORMULAS TO THE COTTAGE CITY WATERSPOUT, CHAMBERLAIN 2D A.

The primary difference between the funnel-shaped and the dumb-bell-shaped vortex tube is that the former extends from its asymptotic relation at one plane of reference, in the base of the cloud, perpendicularly to a great distance from it, tapering continuously to a tube of very small dimensions, while the latter becomes asymptotic to two planes of reference, one in the cloud base and the other at or below the surface of the sea. Not only is the distance between the two reference planes to be measured in meters, but the axis or connecting line is also to be divided into 180 parts or degrees. Thus, in Fig. 3, assume that the upper line is 1200 meters from the lower line, that the axis is of the same length, and that this represents the entire vortex. If this length is taken as 180° or parts then the a appearing in the formulas is

$$a = \frac{180}{1200} = 0.150 \; [9.17609],$$

which gives the angular change per meter. Since the symmetry of the formulas, as controlled by the sine and cosine terms, shows that the variations lie between + 1 and − 1, it follows that $\sin a z$ and $\cos a z$ will carry the function thru all the intermediate values. Fig. 3 is constructed by plotting the lines determined by the coordinates of Table 17, which gives the radii ϖ of the several tubes at different heights z.

Since there is no way to determine the value of the tangential velocity at any given point, it is necessary to assume a value for v at a point (ϖ, z). The correctness of the one adopted can be checked by constructing the vortex from these data, and comparing it with the shape as shown on the photograph. The height z was determined as about 1200 meters by the measurements, and after several trials I have taken

$$a z = 170° \text{ or } 10°,$$
$$\varpi = 200 \text{ meters},$$
$$v = 2 \text{ meters per second}.$$

The value $a z = 10°$ is for a point near the sea level, and the value $a z = 170°$ is for a point just below the cloud base. Hence we have the current function,

$$a\psi = v\varpi = 400 \; [2.60206].$$

For the value of the ratio of the successive radii, at the points separated by 10-millimeter intervals of pressure, as 760, 750 ...... 690, we shall assume the same value as that given on page 469, whose logarithm is,

$$\log \rho = 0.20546.$$

These data enable us to proceed with the computations in the regular order, and to develop the entire structure of this

vortex. It is most convenient to compute the values of ϖ, v, A, u, and w on one selected level, as that for $az = 10°$, and then to extend the computation to the same quantities on the other levels by the use of the formulas 38–49, given in the preceding paper of this series.

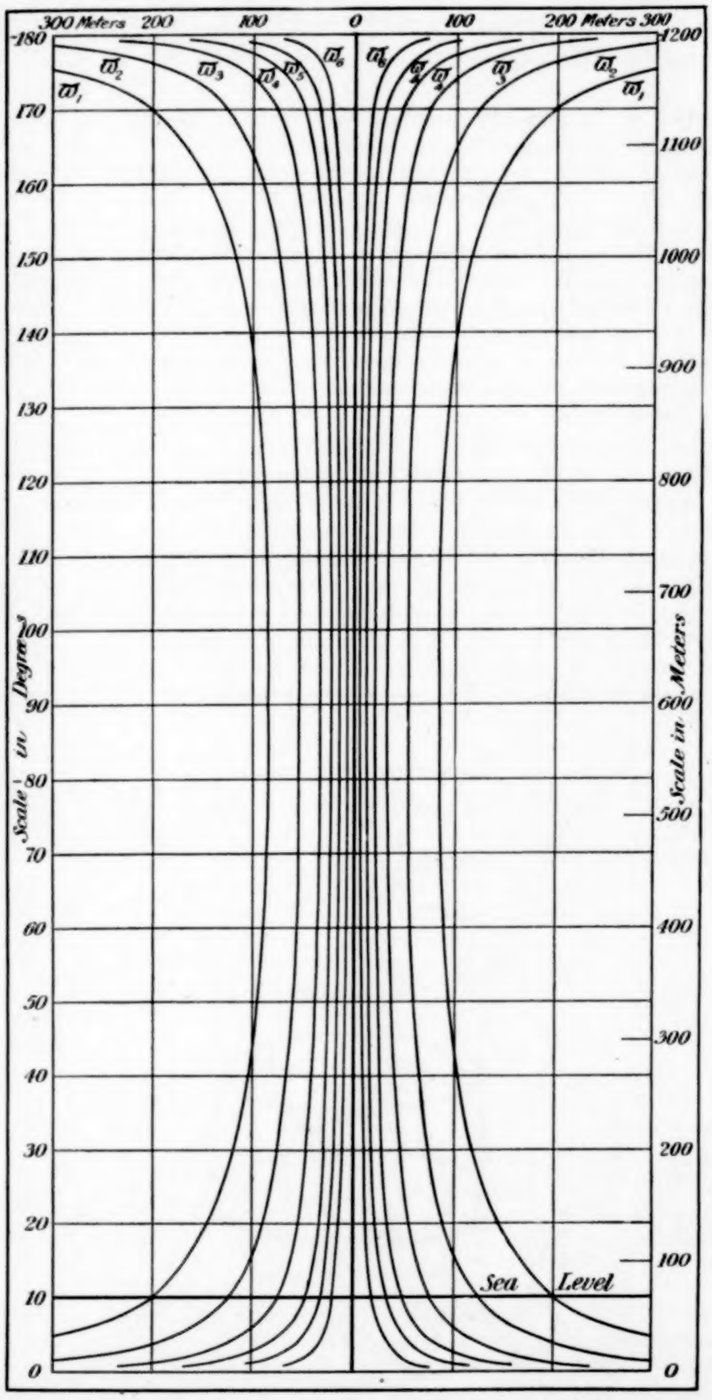

FIG. 3.—Vertical section thru the waterspout, showing the relation between ϖ and z. The tubes ϖ_1 and ϖ_2 are developed only during the time of dissipation of the vortex, and probably tubes ϖ_7 and ϖ_8 are not actually developed in this vortex.

SUMMARY OF THE CONSTANTS FOR THE COMPUTATION ON THE PLANE $az=10°$.

$$\log a\psi = \log v\varpi = 2.60206$$

$$\log \rho = \log \frac{\varpi_n}{\varpi_{n+1}} = 0.20546$$

$$\log \sin az = \log \sin 10° = 9.23967$$
$$\log \cos az = \log \cos 10° = 9.99335$$
$$\log a \sin az = \log a \sin 10° = 8.41576$$
$$\log a \cos az = \log a \cos 10° = 9.16944$$
$$\log a = \log 0.150 = 9.17609$$

Take the intervals determined by the log ρ as the points for the computation.

TABLE 13.—*The radii of the successive vortex tubes, $\log \varpi_{n+1} = \log \varpi_n - \log \rho = \log \varpi_n - 0.20546$.*

	Number of line.*							
	1	2	3	4	5	6	7	8
log ϖ	2.30103	2.09557	1.89011	1.68465	1.47919	1.27373	1.06827	0.86281
ϖ	200.0	124.6	77.6	48.4	30.1	18.8	11.7	7.3

*The word "line" here, and in subsequent tables and text, refers to the numbered lines of figure 3, which represent curved surfaces, bounding successive vortex tubes, taken for purposes of computation.

The successive radii on the same plane are found by subtracting log $\rho = 0.20546$ from the values in the preceding columns.

TABLE 14.—*The tangential velocities, $\log v_{n+1} = \log v + \log \rho = \log v + 0.20546$.*

log v	0.30103	0.50649	0.71195	0.91741	1.12287	1.32833	1.53379	1.73925
v	2.0	3.2	5.2	8.3	13.3	21.3	34.2	54.9

The several velocities on the same plane are found by adding log $\rho = 0.20546$ in succession.

To compute the constant A for each of the successive vortex tubes we construct the values of log $a\varpi$ sin az and subtract these values from the logarithms of the corresponding velocities v. The constant A holds for each single special tube, but changes its value from one tube to another.

TABLE 15.—*The constant A at the successive vortex tubes.*

log $a\ \varpi$ sin az .	0.71679	0.51133	0.30587	0.10041	9.89495	9.68949	9.48403	9.27857
log A	9.58424	9.99516	0.40608	0.81700	1.22792	1.63884	2.04976	2.46068
A	0.3839	0.9889	2.5473	6.5614	16.9010	43.5350	112.1400	285.853

In forming the log $a\varpi$ sin az, the log ρ is subtracted in succession, and in forming the log A, 2 log ρ is added successively.

To compute the radial velocity u, and the vertical velocity w, the values of log $Aa\varpi$ and $2A$ are constructed, and log cos az and log sin az added to them respectively.

TABLE 16.—*The radial and vertical velocities for each vortex tube.*

	1	2	3	4	5	6	7	8
log $Aa\varpi$	1.06136	1.26682	1.47228	1.67774	1.88320	2.08866	2.29412	2.49958
log u...	−1.05471	−1.26017	−1.46563	−1.67109	−1.87655	−2.08201	−2.28747	−2.49293
u...	− 11.34	− 18.20	− 29.22	− 46.89	− 75.26	− 120.79	− 193.85	− 311.12
log $2A$..	9.88527	0.29619	0.70711	1.11803	1.52895	1.93987	2.35079	2.76171
log w..	9.12494	9.53586	9.94678	0.35770	0.76862	1.17954	1.59046	2.00138
w...	0.13	0.34	0.88	2.28	5.87	15.12	38.95	100.32

Having computed the value of log u under the radius ϖ_1, the others are found by adding log ρ; and the successive values of log w are obtained by adding 2 log ρ to the several values in succession. Since the axis of z is positive upward, the movement of the air in the waterspout is continuously positive and therefore upward; the motion of the radial velocity u is inward in the lower half of the vortex, but outward in the upper half of it.

Having thus found the values of log ϖ, log u, log v, and log w on a given plane of the vortex (in this case the plane which passes thru the point on the axis corresponding to $az=10°$), it is proper next to extend the computation to other

planes by employing the other values of sin az and cos az as required. In order to exhibit the amount of work needed to compute these terms for 10-degree intervals in a vertical direction, and for the stated intervals in a horizontal direction, the computations for log ϖ and ϖ are given in full, those for u, v, and w requiring similar tables.

TABLE 17.—*Computation of log ϖ and ϖ for each tube at successive altitudes.*

Values of log ϖ.

Altitude.	1	2	3	4	5	6	7	8
az = 0°	∞	∞	∞	∞	∞	∞	∞	∞
10	2.30103	2.09557	1.89011	1.68465	1.47919	1.27373	1.06827	0.86281
20	2.15384	1.94838	1.74292	1.53746	1.33200	1.12654	0.92108	0.71562
30	2.07138	1.86592	1.66046	1.45500	1.24954	1.04408	0.83862	0.63316
40	2.01683	1.81137	1.60591	1.40045	1.19499	0.98953	0.78407	0.57861
50	1.97874	1.77328	1.56782	1.36236	1.15690	0.95144	0.74598	0.54052
60	1.95210	1.74664	1.54118	1.33572	1.13026	0.92480	0.71934	0.51388
70	1.93437	1.72891	1.52345	1.31799	1.11253	0.90707	0.70161	0.49615
80	1.92419	1.71873	1.51327	1.30781	1.10235	0.89689	0.69143	0.48597
90	1.92086	1.71540	1.50994	1.30448	1.09902	0.89356	0.68810	0.48264

Values of the radius ϖ for each tube and altitude.

Altitude.	1	2	3	4	5	6	7	8	C
az = 0°	∞	∞	∞	∞	∞	∞	∞	∞	
10	200.0	124.6	77.6	48.4	30.1	18.8	11.7	7.3	60
20	142.5	88.8	55.3	34.3	21.5	13.4	8.3	5.2	
30	117.9	73.4	45.8	28.5	17.8	11.1	6.9	4.3	36
40	103.9	64.8	40.4	25.1	15.7	9.8	6.1	3.8	
50	95.2	59.3	37.0	23.0	14.4	8.9	5.6	3.5	34
60	89.6	55.8	34.8	21.6	13.5	8.4	5.2	3.3	
70	86.0	53.6	33.4	20.8	13.0	8.1	5.0	3.1	30
80	84.0	52.3	32.6	20.3	12.7	7.9	4.9	3.06	
90	83.3	51.9	32.4	20.2	12.6	7.8	4.9	3.04	28
100	84.0	52.3	32.6	20.3	12.7	7.9	4.9	3.06	
110	86.0	53.6	33.4	20.8	13.0	8.1	5.0	3.1	30
120	89.6	55.8	34.8	21.6	13.5	8.4	5.2	3.3	
130	95.2	59.3	37.0	23.0	14.4	8.9	5.6	3.5	33
140	103.9	64.8	40.4	25.1	15.7	9.8	6.1	3.8	
150	117.9	73.4	45.8	28.5	17.8	11.1	6.9	4.3	39
160	142.5	88.8	55.3	34.3	21.5	13.4	8.3	5.2	
170	200.0	124.6	77.6	48.4	30.1	18.8	11.7	7.3	68
180	∞	∞	∞	∞	∞	∞	∞	∞	

The last column, marked C, in the second portion of Table 17, contains the radius as scaled from the photograph, and it indicates that the vapor tube is a vortex lying a little inside the radius ϖ_s on the scale adopted. The radii fluctuate considerably in a natural vortex, as may be seen by comparing Chamberlain 2d A with Coolidge 2d B, 2d F, 2d G, and the selection of the data belonging to a given vortex is not easy, when no observations are available. The barometric pressure in vortices of this type will be considered fully in connection with hurricanes.

THE VELOCITIES IN THE COTTAGE CITY WATERSPOUT.

TABLE 18.—*The radial velocities u for each tube and altitude.*

Altitude.	logs	1	2	3	4	5	6	7	8
az=0°	−1.06136	−11.52	−18.49	−29.67	−47.61	−76.42	−122.65	−196.85	−315.92
10	−1.05471	−11.34	−18.20	−29.22	−46.89	−75.26	−120.78	−193.85	−311.12
30	−0.99889	− 9.97	−16.01	−25.69	−41.24	−66.18	−106.22	−170.47	−273.59
50	−0.86943	− 7.40	−11.88	−19.07	−30.61	−49.12	− 78.84	−126.53	−203.07
70	−0.59541	− 3.94	− 6.32	−10.15	−16.28	−26.14	− 41.95	− 67.32	−108.05
90	−∞	0	0	0	0	0	0	0	0
110	0.59541	3.94	6.32	10.15	16.28	26.14	41.95	67.32	108.05
130	0.86943	7.40	11.88	19.07	30.61	49.12	78.84	126.53	203.07
150	0.99889	9.97	16.01	25.69	41.24	66.18	106.22	170.47	273.59
170	1.05471	11.34	18.20	29.22	46.89	75.26	120.78	193.85	311.12
180	1.06136	11.52	18.49	29.67	47.61	76.42	122.65	196.83	315.92

TABLE 19.—*The tangential velocities v for each tube and altitude.*

az=0°	−∞	0	0	0	0	0	0	0	0
10	0.30103	2.00	3.21	5.15	8.27	13.27	21.30	34.18	54.86
30	0.76033	5.76	9.24	14.83	23.81	38.21	61.32	98.42	157.97
50	0.94561	8.82	14.16	22.73	36.47	58.54	93.95	150.79	242.01
70	1.03435	10.82	17.37	27.88	44.74	71.81	115.25	184.98	296.87
90	1.06136	11.52	18.48	29.67	47.61	76.42	122.65	196.84	315.92
110	1.03435	10.82	17.37	27.88	44.74	71.81	115.25	184.98	296.87
130	0.94561	8.82	14.16	22.73	36.47	58.54	93.95	150.79	242.01
150	0.76033	5.76	9.24	14.83	23.81	38.21	61.32	98.42	157.97
170	0.30103	2.00	3.21	5.15	8.27	13.27	21.30	34.18	54.86
180	−∞	0	0	0	0	0	0	0	0

TABLE 20.—*The vertical velocities w for each tube and altitude.*

az=0°	−∞	0	0	0	0	0	0	0	0
10	9.12494	0.13	0.34	0.88	2.28	5.87	15.12	38.94	100.32
30	9.58424	0.38	0.99	2.54	6.56	16.90	43.54	112.14	288.86
50	9.76952	0.58	1.52	3.90	10.05	25.89	66.70	171.81	442.55
70	9.85826	0.72	1.86	4.79	12.33	31.76	81.82	210.76	542.88
90	9.88527	0.77	1.98	5.10	13.12	33.80	87.07	224.28	577.71
110	9.85826	0.72	1.86	4.79	12.33	31.76	81.82	210.76	542.88
130	9.76952	0.58	1.52	3.90	10.05	25.89	66.70	171.81	442.55
150	9.58424	0.38	0.99	2.54	6.56	16.90	43.54	112.14	288.86
170	9.12494	0.13	0.34	0.88	2.28	5.87	15.12	39.94	100.32
180	−∞	0	0	0	0	0	0	0	0

The radial velocity reverses direction at az=90°; it is very large in the inner tubes, increasing toward the axis. The tangential velocity is right-handed for upward velocities, so that v and w are both positive for an axis drawn as in fig. 3. The enormous velocities which are developed near the axis, especially the vertical velocity, show where the destructive forces reside that are associated with tornadoes and waterspouts. The hurricane also will develop velocities of a very high order. It is quite probable that the tubes under (1), (2), (7), and (8) did not develop in the vortex of the Cottage City waterspout, tho covered by the computation, which extends beyond the probable limits.

THE HORIZONTAL ANGLE i AND THE VERTICAL ANGLE η OF THE CURRENT q IN THE VORTEX.

As the angles of reference of the current, whose total velocity is q (u, v, w) at the point (ϖ, φ, z), we have taken i and η; i is the angle between the tangent to the circle whose radius is ϖ and the horizontal component σ, positive outward; η is the angle between σ and q, σ being the projection of q on the horizontal plane. (See fig. 4.)

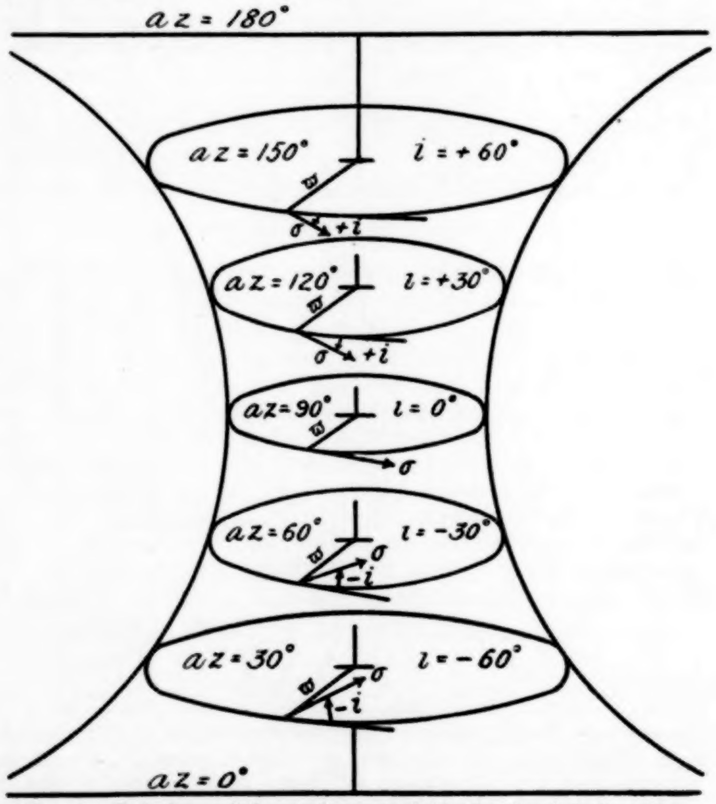

FIG. 4.—Relations of the angles az and i in the dumb-bell vortex.

$$az = 90° + i$$

$\tan i = \dfrac{u}{v}$, constant on any plane az.

$\tan \eta = \dfrac{w}{v \sec i}$ { increases from az=0° to az=90° and from ϖ, toward the axis.

(Compare fig. 1, page 464.)

The horizontal angle i is directed inward from $az=0°$ to $az=90°$, and outward from $az=90°$ to $az=180°$. This angle i is computed from

$$\tan i=\frac{u}{v},$$

and it is constant on the same plane az.

TABLE 21.—*The horizontal angle i, negative inward, positive outward.*

Height by angular measure.		1	2	3	4	5	6	7	8
°	°	°	°	°	°	°	°	°	°
az=180°	0°	−90	−90	−90	−90	−90	−90	−90	−90
170	10	−80	−80	−80	−80	−80	−80	−80	−80
160	20	−70	−70	−70	−70	−70	−70	−70	−70
150	30	−60	−60	−60	−60	−60	−60	−60	−60
140	40	−50	−50	−50	−50	−50	−50	−50	−50
130	50	−40	−40	−40	−40	−40	−40	−40	−40
120	60	−30	−30	−30	−30	−30	−30	−30	−30
110	70	−20	−20	−20	−20	−20	−20	−20	−20
100	80	−10	−10	−10	−10	−10	−10	−10	−10
90	90	−0	−0	−0	−0	−0	−0	−0	−0

The angle i is negative from $az=0°$ to $az=90°$ and positive from $az=90°$ to $az=180°$.

The stream lines are directed toward the axis on the lower asymptotic plane, and gradually incline from the radius as the height, measured by the angle az, increases, so that

(50) $$az=90°+i \text{ or } i=az-90°.$$

When $az=90°$ the angle $i=0°$, and the current is parallel to the circle described by the radius ϖ, but from that level to $az=180°$, i is positive and becomes 90° for $az=180°$, that is, on the upper asymptotic plane at the base of the cloud. It follows that the angle i can be inferred from the height az above the lower plane, or from measured values of the angle i the height az can be immediately found. If on a given plane, as the sea level, the currents of wind are observed to flow into a vortex at a certain angle, i, measured from the tangent, or at the angle az measured from the radius, it follows that the vortex is truncated by the sea level on that plane, and that the truncating plane can thus be drawn thru a theoretical vortex, this being the plane at which the complete vortex has been cut off by rotating against the surface of the sea.

TABLE 22.—*The vertical angle η, $\tan \eta=\frac{w}{v \sec i}$.*

Height by angular measure.		1	2	3	4	5	6	7	8
°	°	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
az=180	0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
170	10	0 40	1 4	1 42	2 44	4 24	7 2	11 11	17 37
160	20	1 18	2 6	3 22	5 23	8 36	13 39	21 17	32 1
150	30	1 55	3 4	4 55	7 51	12 28	19 33	29 40	42 26
140	40	2 27	3 56	6 18	10 3	15 52	24 32	36 13	49 37
130	50	2 55	4 41	7 30	11 55	18 43	28 32	41 11	54 29
120	60	3 18	5 18	8 28	13 25	20 58	31 35	44 37	57 44
110	70	3 35	5 44	9 10	14 31	22 34	33 43	46 57	59 48
100	80	3 45	6 1	9 36	15 11	23 32	34 57	48 18	60 57
90	90	3 49	6 6	9 45	15 25	23 52	35 22	48 44	61 29

It will be shown that cyclones, hurricanes, and tornadoes develop at the upper plane and extend downward toward the surface, the lower portion of the vortex being destroyed in the working of the tube against the sea or the land surface. Thus in the cyclones the central plane for $az=90°$ is in the strato-cumulus level, where the angle az is about 50° or 60°, making $i=-40°$ or $-30°$, which is the angle usually measured on the inflowing current. In the hurricane the central plane is somewhat higher, while in the Cottage City waterspout it is about 80° above the sea level, making the inflowing current at the bottom of the cascade construct an angle of 10° from the radius. It is such an action of the dumb-bell vortex in developing the angles in this manner, with the inflowing angle constant on a given plane, and proportional to the height from the plane of reference, which produces the angles observed in cyclones and hurricanes, rather than the friction k, the deflecting force λ, and the vertical constant c, as was assumed by Ferrel and the German writers in their studies of the problem. We have, therefore, in practise only to measure the velocity and angle of inflow on a given plane, as the land or the sea level, truncate the theoretical vortex at the corresponding plane, and proceed to develop the velocities and angles thruout the entire vortex to the cloud level where it is actually generated.

The angle η is positive from $az=0°$ to $az=180°$. The angle η increases from $az=0°$ to $az=90°$, and it decreases from $az=90°$ to $az=180°$; the angle increases from the outer line toward the axis, and in the middle of the vortex on the plane $az=90°$ at line 8 it may reach about 61°. The sec i can not be neglected in this computation, as the angle i is of all values from 0° to 90°.

The total velocity can be computed from the formulas,

$$q=(u^2+v^2+w^2)^{\frac{1}{2}}, \text{ or}$$
$$q=v \sec i \sec \eta.$$

TABLE 23.—*The total velocity q, in meters per second.*

Height by angular measure.		1	2	3	4	5	6	7	8
°	°								
az=180	0	11.52	18.49	29.67	47.61	76.42	122.65	196.83	315.47
170	10	11.52	18.49	29.68	47.62	76.64	123.58	200.65	331.47
160	20	11.52	18.50	29.72	47.83	77.29	126.21	211.25	372.60
150	30	11.52	18.51	29.78	48.07	78.26	130.15	226.53	428.06
140	40	11.53	18.53	29.85	48.36	79.45	134.82	243.98	487.61
130	50	11.53	18.55	29.92	48.66	80.69	139.60	261.50	543.81
120	60	11.54	18.56	30.00	48.95	81.84	143.97	276.53	591.77
110	70	11.54	18.58	30.05	49.18	82.75	147.45	288.36	628.04
100	80	11.54	18.59	30.09	49.34	83.35	149.63	295.91	650.63
90	90	11.54	18.59	30.10	49.39	83.56	150.40	298.44	658.57

The visible vortex, as it develops in the atmosphere, is probably confined within the lines 3, 4, 5, and 6, tho possibly extending a little beyond ϖ_6.

The volume of air V, in cubic meters per second, which passes upward thru each vortex tube, is computed from the formula,

$$V=\pi\,(\varpi_n^2-\varpi_{n+1}^2)\,w_m = \text{a constant},$$

w_m being the mean velocity, as obtained by the formula,

$$\log w_m = \tfrac{1}{2}\,(\log w_n + \log w_{n+1}).$$

The value of V is computed for three levels, and the result is given in Table 24, taking the values of log ϖ and log w from Tables 17 and 20.

TABLE 24.—*The volume of air ascending in each vortex tube.*

Height of stratum.	1–2	2–3	3–4	4–5	5–6	6–7	7–8
$az=10°$	16451.5	16451.5	16451.5	16451.5	16451.5	16451.5	16451.5
$az=30°$	16451.5	16451.5	16451.5	16451.5	16451.5	16451.5	16451.5
$az=90°$	16451.5	16451.5	16451.5	16451.5	16451.5	16451.5	16451.5

In the funnel-shaped vortex it was found that the volume of ascending air was 2467.7 cubic meters per second, so that the *dumb-bell vortex is carrying 6.666 times as much air upward as the funnel-shaped vortex.* It may be inferred that the change from one type of vortex to the other is due to the requirements of the temperature conditions at the cloud, the greater changes due to the overflowing cold sheet demanding a stronger upflow in the dumb-bell vortex, the smaller changes in temperature in the horizontal sheet being satisfied by the feebler action of the funnel-shaped vortex. This becomes equivalent to the statement that at the immediate base of the cloud the horizontal velocity u is stronger in the dumb-bell vortex than in the funnel-shaped vortex.

EVALUATION OF THE EQUATIONS OF MOTION.

In the future chapters we shall fully consider all the forces and conditions that appreciably affect vortex motions, but for the present we shall consider only the simplified equations of motion that apply to the case of no inertia, no friction, and no deflecting force. In this case the equations of motion of a vortex (see No. (6), page 465, or Cloud Report, 1898, page 504, equation 200, and page 502, equation 180) become,

$$\begin{cases} (1) & -\dfrac{\partial P}{\rho \partial \varpi} = u \dfrac{\partial u}{\partial \varpi} + w \dfrac{\partial u}{\partial z} - \dfrac{v^2}{\varpi}, \\ (2) & \quad 0 = u \dfrac{\partial v}{\partial \varpi} + w \dfrac{\partial v}{\partial z} + \dfrac{uv}{\varpi}, \\ (3) & -\dfrac{\partial P}{\rho \partial z} = u \dfrac{\partial w}{\partial \varpi} + w \dfrac{\partial w}{\partial z} + g. \end{cases}$$

The partial differentials of the velocity in the direction of the radius ϖ and the vertical z can be computed in terms of the constants of the vortex, from the equation for the current function,

$$\psi = A\, \varpi^2 \sin az.$$

Thus we find the partial differentials of the velocities as follows:

$$(51) \quad \begin{cases} u = -A\, a\, \varpi \cos az. & v = A\, a\, \varpi \sin az. & w = 2\, A \sin az. \\ \dfrac{\partial u}{\partial \varpi} = -A\, a \cos az. & \dfrac{\partial v}{\partial \varpi} = A\, a \sin az. & \dfrac{\partial w}{\partial \varpi} = 0. \\ \dfrac{\partial u}{\partial z} = A\, a^2\, \varpi \sin az. & \dfrac{\partial v}{\partial z} = A\, a^2\, \varpi \cos az. & \dfrac{\partial w}{\partial z} = 2\, A\, a \cos az. \end{cases}$$

The products of these quantities are then formed as follows:

$$(52) \quad \begin{cases} u \dfrac{\partial u}{\partial \varpi} = A^2 a^2\, \varpi \cos^2 az. & w \dfrac{\partial u}{\partial z} = 2\, A^2 a^2\, \varpi \sin^2 az. \\ u \dfrac{\partial v}{\partial \varpi} = -\ A^2 a^2\, \varpi \sin az \cos az. & w \dfrac{\partial v}{\partial z} = 2\, A^2 a^2\, \varpi \sin az \cos az. \\ u \dfrac{\partial w}{\partial \varpi} = 0. & w \dfrac{\partial w}{\partial z} = 4\, A^2 a \sin az \cos az. \\ \dfrac{v^2}{\varpi} = A^2 a^2\, \varpi \sin^2 az. & \dfrac{uv}{\varpi} = -\ A^2 a^2\, \varpi \sin az \cos az. \end{cases}$$

Hence, the three equations of motion as above given reduce to,

$$(53) \quad \begin{cases} (1) & -\dfrac{\partial P}{\rho \partial \varpi} = A^2 a^2\, \varpi. \\ (2) & \quad 0 = 0. \\ (3) & -\dfrac{\partial P}{\rho \partial z} = g + 4\, A^2 a \sin az \cos az. \end{cases}$$

The second equation reduces to zero.

AN EXAMPLE.

TABLE 25—*Collection of the data for an example in computing the equations of motion for any special radius ϖ and level az.*

Data.	1	2	3	4	5	6	7	8
log A . . .	9.58424	9.99516	0.40608	0.81700	1.22792	1.63884	2.04976	2.46068
A	0.3839	0.9889	2.5473	6.5614	16.9010	43.5350	112.140	288.853
log ϖ_{10} .	2.30103	2.09557	1.89011	1.68465	1.47919	1.27373	1.06827	0.86281
ϖ_{20} .	2.15384	1.94838	1.74292	1.53746	1.33200	1.12654	0.92108	0.71562
ϖ_{10} .	200.0	124.6	77.6	48.4	30.1	18.8	11.7	7.3
ϖ_{20} .	142.5	88.8	55.3	34.3	21.5	13.4	8.3	5.2
log u_{10} . .	−1.05471	−1.26017	−1.46563	−1.67109	−1.87655	−2.08201	−2.28747	−2.49293
u_{20} . .	−1.03435	−1.23981	−1.44527	−1.65073	−1.85619	−2.06165	−2.26711	−2.47257
u_{10} . .	−11.84	−18.20	−29.22	−46.89	−75.26	−120.78	−193.85	−311.12
u_{20} . .	−10.82	−17.37	−27.88	−44.74	−71.81	−115.25	−184.93	−296.86
log v_{10} . .	0.30103	0.50649	0.71195	0.91741	1.12287	1.32833	1.53379	1.73925
v_{20} . .	0.59541	0.80087	1.00633	1.21179	1.41725	1.62271	1.82817	2.03363
v_{10} . .	2.00	3.21	5.15	8.27	13.27	21.30	34.18	54.86
v_{20} . .	3.94	6.32	10.15	16.29	26.14	41.95	67.32	108.05
log w_{10} . .	9.12494	9.53586	9.94678	0.35770	0.76862	1.17954	1.59046	2.00138
w_{20} .	9.41932	9.83024	0.24116	0.65208	1.06300	1.47392	1.88484	2.29576
w_{10} . .	0.13	0.34	0.88	2.28	5.87	15.12	38.94	100.32
w_{20} . .	0.26	0.68	1.74	4.49	11.56	29.78	76.71	197.59

An example of the practical working of these equations may be taken from the data of the preceding tables, which are collected for convenience in Table 25. The point selected is on the level $az=10°$ and between the radii ϖ_3 and ϖ_4, intending to integrate across the tube $\varpi_3-\varpi_4$ at the level $az=10°$ and vertically thru this point from $az=5°$ to $az=15°$.

The interpolations are to be made at the middle point of the tube $(\varpi_3-\varpi_4)$ and on the plane $az=10°$.

The arrangement of the computations for each side of each equation (thus checking the theory from two points of view) is as follows:

$$u \frac{\partial u}{\partial \varpi} = A^2 a^2\, \varpi \cos^2 az.$$

Left-hand term.			Right-hand term.	
Term.	Number.	Logarithm.	Term.	Logarithm.
u_m	−37.01	−1.56836	A^2	1.22308
∂u	−17.67	−1.24724	a^2	8.35218
$\partial \varpi$	+29.20	1.46528	ϖ	1.78738
			$\cos^2 az$	9.98670
$u \dfrac{\partial u}{\partial \varpi}$	22.40	1.35022	22.35	1.34934

$$u\frac{\partial v}{\partial \varpi}=-A^2a^2\varpi \sin az \cos az.$$

Left-hand terms.			Right-hand terms.	
Term.	Number.	Logarithm.	Term.	Logarithm.
u_m	−37.01	−1.56836	$-A^2a^2\varpi$	−1.36264
∂v	+ 3.12	0.49415	$\sin az$	9.23967
$\partial \varpi$	+29.20	1.46538	$\cos az$	9.99335
$u\frac{\partial v}{\partial \varpi}$	−3.955	−0.59713	−3.942	−0.59556

$$u\frac{\partial w}{\partial \varpi}=0.$$

u_m	−37.01	−1.56836	....	0
∂w	+ 1.40	0.14613		
$\partial \varpi$	+29.20	1.46538		
$u\frac{\partial w}{\partial \varpi}$	−1.775	−0.24911	0	

This discrepancy results from the fact that $\frac{\partial w}{\partial \varpi}$ has a value $\frac{1.40}{29.20}=0.05$, slightly larger than 0.

In evaluating the partial differentials in the direction of the angular coordinate az, the factor 57°.29578 must be introduced into the terms for partial differential, as this is the number of degrees in one radius. Since the angular distance is 180 degrees and the linear distance 1200 meters, the 10-degree interval is equivalent to

$$\partial z=10\text{-degree interval}=\frac{1200}{18}\cdot\frac{1}{57.29578}=1.1636,$$

which is the value of ∂z in the partial differentials.

$$w\frac{\partial u}{\partial z}=2A^2a^2\varpi \sin^2 az.$$

Left-hand terms.			Right-hand terms.	
Term.	Number.	Logarithm.	Term.	Logarithm.
w_m	+1.42	0.15224	2	0.30103
∂u	1.14	0.05690	$A^2a^2\varpi$	1.36264
∂z	1.1636	0.06579	$\sin^2 az$	8.47934
$w\frac{\partial u}{\partial z}$	1.391	0.14335	1.390	0.14301

$$w\frac{\partial v}{\partial z}=2A^2a^2\varpi \sin az \cos az.$$

w_m	1.42	0.15224	$2A^2a^2\varpi$	1.66367
∂v	6.452	0.80969	$\sin az$	9.23967
∂z	1.1636	0.06579	$\cos az$	9.99335
$w\frac{\partial v}{\partial z}$	7.873	0.89614	7.883	0.89669

$$w\frac{\partial w}{\partial z}=4A^2a \sin az \cos az.$$

w_m	1.42	0.15224	$4A^2a$	1.00123
∂w	1.404	0.14737	$\sin az$	9.23967
∂z	1.1636	0.06579	$\cos az$	9.99335
$w\frac{\partial w}{\partial z}$	1.713	0.23382	1.715	0.23425

$$\frac{v^2}{\varpi}=A^2a^2\varpi \sin^2 az.$$

v^2	42.59	1.62936	$A^2a^2\varpi$	1.36264
ϖ	61.29	1.78738	$\sin^2 az$	8.47934
$\frac{v^2}{\varpi}$	0.695	9.84198	0.695	9.84198

$$\frac{uv}{\varpi}=-A^2a^2\varpi \sin az \cos az.$$

u	−37.01	−1.56836	$-A^2a^2\varpi$	−1.36264
v	6.526	0.81468	$\sin az$	9.23967
ϖ	61.29	1.78738	$\cos az$	9.99335
$\frac{uv}{\varpi}$	−3.941	−0.59566	−3.941	−0.59566

With these values, our equations of motion for the vortex tube, (3)-(4), now become

(1) $$-\frac{\partial P}{\rho\,\partial\varpi}=22.35+1.390-0.695=23.04=A^2a^2\varpi.$$

(2) $$0=-3.942+7.883-3.941=0.$$

(3) $$-\frac{\partial P}{\rho\,\partial z}=-1.775+1.715+g=9.746,$$

since $g=9.806$ at 45° latitude and sea level.

In making the several interpolations for u_m, v_m, w_m, A_m, in preparation for the integration across the intervals $\partial\varpi$ and ∂z the mean values as derived from the mean logarithms were employed. There are several small differences between the above results obtained by computing both sides of the equations independently, but these are largely due to the neglect of the second differentials, because the curves between the initial and final points were not followed exactly in this integration. The terms in the A_m are more accurate than the others, as here computed.

The pressure at the sea-level plane.

The computation of the pressure at the level defined by $az=10°$, that is the assumed sea level, is made by the formula,

$$P_n-P_{n+1}=\rho_m A^2a^2\varpi\,(\varpi_n-\varpi_{n+1}),$$

which is easily deduced from the first equation of motion (equation 53),

$$-\frac{\partial P}{\rho\partial\varpi}=A^2a^2\varpi,$$

and gives the results found in Table 26.

TABLE 26.—*Fall in pressure between the successive vortex rings.*

Rings.	1-2	2-3	3-4	4-5	5-6	6-7	7-8
$A^2a^2\varpi$	1.349	5.575	23.05	95.28	393.91	1628.5	6732.3
$\varpi_n-\varpi_{n+1}$	75.4	47.0	29.2	18.3	11.3	7.1	4.4
ρ_m	1.2682	1.2682	1.2682	1.2682	1.2682	1.2682	1.2682
P_n-P_{n+1}	126.0	332.3	853.5	2211.3	5645.0	14663.	37563.
B_n-B_{n+1}	0.94	2.49	6.40	16.58	42.34	110.0	281.7

When a waterspout descends to sea level it is equivalent to assuming that the pressure falls at the core by the amount of the computed difference in pressure between the sea level and the base of the cumulus cloud, or, in this case, 91 millimeters. Starting from the assumed outer ring (3), we compute the difference of the barometric pressure, 6.40 + 16.58 + 42.34 + 26.00 = 91.32 millimeters. Hence, it follows that the calm core is to be limited at about 16 meters, as can be seen by comparing Table 26 with the radii ϖ of the rings in Table 25, since the 26.00 millimeters of pressure must be distributed beyond ϖ_6 in the direction of ϖ_7.

THE CASCADE OF THE COTTAGE CITY WATERSPOUT.

The photographs, Chamberlain 2d A in particular, show that the bottom of the tube near the ocean is surrounded by a vaporous mass of rounded form, which I have analyzed as follows: The vortex tube approaches the sea level with violent radial, tangential and vertical components of velocity, sharply separated from the quiet air surrounding it, at the outermost layer of the revolving vortex. Were there no ocean or obstacle to disturb the vortex motion, and were the tube to form in a frictionless medium, the tube would extend to the asymptote at a given distance, leaving a small calm core free from gyration. But in fact the tube encounters the waters of the ocean, and becomes distorted by the action of the conflicting forces. The most prominent effect is the change in the size of the tube, and the decrease of gyratory velocity in consequence of friction and the other forces, caused by the transfer of the energy of the tube to the masses of air and water, wherein the forces of inertia are very large, since quiet air and water are suddenly set in violent motion on meeting the vortex. The intake of the vortex, due to the strong ascending helical motion, requires a supply of air which enters the tube by curved paths, as shown on the photograph by the clear spaces near the surface of the ocean. The water itself leaps up a few feet at the center into a point, or conical wave, and a sharp measure of this distance is desirable as the pressure-fall in the center of the tube can be estimated from it. The circular rotation of the tube at the surface cuts up the water into drops of spray, which are drawn into the tube, together with the air moving toward the axis.

At a certain height above the surface where the intake has become satisfied, and there are only small radial components setting inward, the water and spray are thrown by the centrifugal and deflecting forces outward from the tube at the height of about 110 meters. This mass of air and water inside the tube is gyrating violently, but on being ejected from the tube it impinges upon the quiet air and loses its projectile energy upward and outward, so that it falls back to the ocean in a cascade. The falling spray is again sucked into the tube on approaching the levels where the intake begins, and the orbital rotation may be thus repeated more than once. It is evident that there is a series of beautiful mechanical problems in this connection, but it is not easy to treat them fully, because the size of the drops, the action of viscosity on the velocity, and the velocity components themselves are not fully known. Since the formulas for the vortex apply to media without friction and to parabolic trajectories, it is difficult to modify them to meet the actual atmospheric conditions. There is evidently a right-hand and a left-hand trajectory, so that the origin of coordinates (x, z) can be taken at the axis of the vortex as it touches the water; x is along the surface, and z is perpendicular to it along the axis of the tube. I have written down the formulas for the parabolic trajectories, which can be readily understood from fig. 5.

Some computations of a parabola thru the points ($x_1=0$, $z_1=0$) and ($x_2=55$, $z_2=128$) show that this parabola is too sharp near the vortex for the trajectory of the spray, and accordingly some other curves have been sketched in, showing the boundary of the water cascade, and some arrows indicating the paths of the water drops, the spray and the air, which seem to conform to the design on Chamberlain's photograph. To pass from the pure parabola to the actual paths of the water and spray masses is probably quite impracticable by mathematical analysis, till we know more of the size of the water masses, the viscosity, and the actual velocities in the several parts of the disturbed tube, especially in the stream lines near the surface where the vortex forces are seriously disturbed by composition with the inflowing masses, suddenly changed from rest into violent motion. It is evident that all waterspouts and tornadoes will suck in objects near the surface, and discharge them into the quiet air a few hundred feet above the surface, when they will fall again.

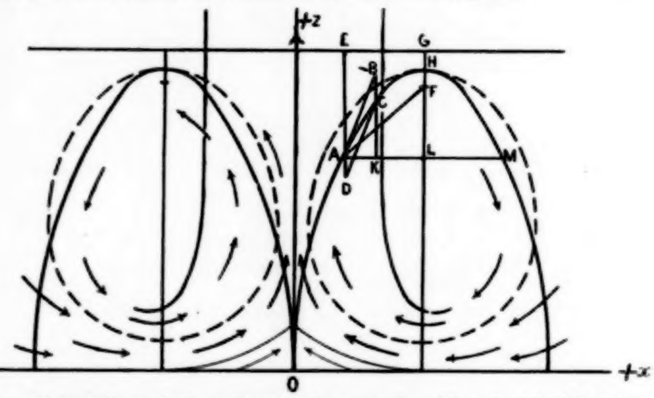

FIG. 5.—Circulation of air and water in cascade. Heaviest full lines, vortex tube. Middle full lines, parabolic trajectories. Lightest full lines, water cone. Dotted ovals, paths of water drops in cascade. Arrows, direction of circulation. Height of cascade = 128 meters. Diameter of cascade = 220 meters. Diameter of vortex tube = 74 meters.

TABLE 27.—*Formulas for parabola.*

$$AB = vt.$$
$$\overline{AB}^2 = v^2t^2. \qquad \overline{AB}^2 = \frac{2v^2}{g} . AD.$$
$$BC = \tfrac{1}{2}gt^2.$$
$$AF = AE = h. \qquad v^2 = 2gh.$$
$$FH = GH.$$
$$EAB = BAF. \qquad \overline{AB}^2 = 4h . AD.$$
$$BAL = a.$$

TABLE 28.—*Equations of parabola.*

$$\left.\begin{aligned} AK &= x = vt\cos a. \\ BK &= vt\sin a. \\ BC &= \tfrac{1}{2}gt^2. \end{aligned}\right\}\text{origin at } A.$$
$$CK = z = vt\sin a - \tfrac{1}{2}gt^2.$$
$$z = x\tan a - \frac{gx^2}{2v^2\cos^2 a}$$
$$z = x\tan a - \frac{x^2}{4h\cos^2 a}$$

TABLE 29.—*Formulas for the angle a, height h, and velocity v (in vacuo) of a parabola thru (x_1z_1), (x_2z_2).*

$$\left.\begin{aligned} z_1 &= x_1\tan a - \frac{x_1^2}{4h\cos^2 a}. \\ z_2 &= x_2\tan a - \frac{x_2^2}{4h\cos^2 a}. \end{aligned}\right\}\text{origin at } O.$$
$$\tan a = \frac{z_1x_2^2 - z_2x_1^2}{x_1x_2(x_2 - x_1)}.$$
$$h = \frac{x_1x_2(x_2 - x_1)}{4\cos^2 a(z_1x_2 - z_2x_1)}.$$
$$v^2 = 2gh = \frac{1}{4\cos^2 a} \cdot \frac{2gx_1x_2(x_2 - x_1)}{z_1x_2 - z_2x_1}.$$
$$\left.\begin{aligned} &\text{Range } AM = 4h\cos a\sin a = 2h\sin 2a. \\ &\text{Time of flight} = t = \frac{4h\sin a}{v} = \frac{2v\sin a}{g}. \\ &\text{Greatest height} = HL = h\sin^2 a. \end{aligned}\right\}\text{origin at } A.$$

THE WEATHER OF THE MONTH.

By Mr. P. C. DAY, Assistant Chief, Division of Meteorological Records.

PRESSURE.

The distribution of mean atmospheric pressure for October, 1907, over the United States and Canada, is graphically shown on Chart VI, and the average values and departures from the normal are shown for each station in Tables I and V.

During October, 1907, the increase in mean pressure over that for September in all the central districts of the United States and Canada was decidedly above the average, ranging from +.10 to +.15 inch, whereas the normal increase is less than .05 inch, except over the upper Missouri Valley and the districts west of the Rocky Mountains where the October pressure averages from .05 to .10 inch above that for September. Over the extreme eastern portion of the Maritime Provinces of Canada, the immediate coast of central and northern California, and the northern portions of Alberta and Saskatchewan the pressure for October, 1907, was slightly less than that for the preceding month.

The average pressure for the month exceeded the normal from .05 to slightly more than .10 inch, over all districts from the Rocky Mountains eastward to the Lake region and the south Atlantic coast. Over New England and the Canadian Maritime Provinces it was slightly below normal, and a similar condition prevailed over California, Oregon, southern Washington, and western Nevada.

The mean pressure for the month was highest, 30.15 or above, over the Ohio Valley and Tennessee, decreasing to 29.95 over the eastern and northern portions of Canada, and to 29.90 over the lower Colorado Valley.

The winds along the Atlantic coast and over the southern Appalachian region during October are normally from the northeast, over the west Gulf, central valleys and lower Lake region from the south, over the upper Missouri Valley from the northwest, while west of the Rocky Mountains they are generally from some westerly point.

During the current month, under the influence of the high pressure in the Ohio Valley, westerly and northerly winds prevailed over the lower Lakes, New England, and nearly the entire Atlantic and Gulf coast districts. Over the central valleys the usual southerly winds prevailed, while west of the Rockies southerly and westerly winds predominated.

Over the Lake region, New England, and the immediate Atlantic coast, storm activity was slightly above the normal, as shown by the increased wind movement, but over nearly all other portions of the United States there was an apparent decrease, the average velocity of the wind movement showing a decrease of from 10 to 30 per cent from the normal.

TEMPERATURE.

The increased pressure over the Ohio Valley and surrounding districts, the general absence of clouds to interfere with radiation at night, and the prevalence of northerly and westerly winds brought much cool, frosty weather to nearly all districts east of the Mississippi River. Over the lower Lakes, New England, and the Middle Atlantic States, the monthly mean temperature was about 4° below the average. In portions of the above districts, especially the lower Lake region, the temperature has averaged below the normal continuously for the seven months, April to October, inclusive.

From the Rocky Mountains westward to the Pacific the reverse of these conditions prevailed. Warm southerly winds penetrated far to the north over the Rocky Mountain and Plateau districts, and at points in the northern portions of those districts it was one of the warmest Octobers in their meteorological history, and marked the breaking up of the period of deficient temperature that had prevailed over those districts since the end of March.

Temperature extremes were generally within the usual October limits. Maximum temperatures from 90° to 96° were recorded in central Texas, and from 90° to slightly more than 100° in the central valleys of California and over southwestern Arizona. Over northern New England maximum temperatures did not go above 70°.

Freezing temperatures penetrated into the northern portion of the cotton region States and occurred generally at exposed points in the mountain and Plateau districts. Over the lower elevations of California, the western portions of Oregon and Washington, and in the Snake River Valley of Idaho, the minimum temperatures were well above the freezing point and no damaging frosts occurred.

PRECIPITATION.

The distribution of precipitation during October, 1907, is graphically shown on Chart IV by appropriate shading or by figures representing the actual amount of fall.

During October the precipitation is usually heaviest along the south Atlantic and north Pacific coasts, where the amount of fall ranges from about 6 inches on the North Carolina coast to slightly more than 10 inches on the coast of Florida, and from about 3 inches on the northern California coast to more than 8 inches on the northern coast of Washington. During October, 1907, the precipitation was markedly deficient over the above-mentioned districts, and the area of heaviest precipitation covered portions of southern and western Texas and central Arizona, where normally the rainfall is less than in any other portion of the United States.

Precipitation was above the normal over the higher elevations of New England, in New York, the lower Lake region, portions of the Ohio Valley, and generally over the entire southern half of the United States from the Mississippi River west to the Pacific Ocean.

Over portions of southern and western Texas the monthly precipitation ranged from 6 to 10 inches, and over central Arizona from 4 to 8 inches, amounts far in excess of the usual fall for those regions.

Precipitation was unusually light over the South Atlantic and east Gulf States and the Florida Peninsula, where the total fall was generally less than 30 per cent of the normal, and in portions of North Carolina and South Carolina, it was less than 10 per cent of the normal.

Precipitation was deficient over the entire northern half of the country from the upper Lakes westward to the Pacific coast; the deficiency over western Oregon and the Puget Sound and coast districts of Washington ranging from 2 to more than 4 inches.

Rain occurred at unusually frequent intervals over Texas, New Mexico, and Arizona, and over California after the 20th, and the streams of those districts, especially in Arizona, were maintained at unusually high stages for the season.

Over the east Gulf and South Atlantic States showers were of infrequent occurrence, with practically no precipitation over large sections of those States from the 10th to 26th.

Heavy rains occurred over the greater part of the Middle Atlantic States and New England from the 27th to 29th.

Over the northern districts from the Lake region to the Pacific the precipitation occurred as light local showers.

SNOWFALL.

There was a rather marked absence of snowfall over the northern Rocky Mountain districts, but depths of several inches were recorded over the high elevations of Colorado and northern Arizona. Considerable snow fell over the interior of New England and in the Appalachian Mountain districts from New York to Virginia.

HUMIDITY AND SUNSHINE.

Relative humidity averaged from 5 to 10 per cent below the normal over the entire Atlantic coast and east Gulf districts, and from the upper Lakes westward to the Rocky Mountains. Over the remaining districts the relative humidity was above the normal, being especially high over Texas and the greater part of the Rocky Mountain and Plateau districts, where the averages ranged from 10 to 30 per cent above the normal, making the tenth consecutive month during which the relative humidity has persistently remained above the normal over the greater part of the districts last mentioned.

There was a general excess of sunshine over all northern and eastern portions of the United States, especially along the Atlantic coast and over the northern Rocky Mountain and Plateau districts, where the amount of sunshine ranged from 70 to 80 per cent of the possible.

Over the districts from the lower Mississippi Valley westward to the Pacific much cloudy weather prevailed, the amounts of sunshine being generally less than 50 per cent of the possible.

WEATHER IN ALASKA.

Reports from the southern coast stations show the usual heavy October rainfall, varying from about 10 inches in the Sitka district to nearly 30 inches in the vicinity of Cook Inlet and at the mouth of the Copper River.

Meager reports from the interior districts indicate that considerable snow occurred, and the covering on the ground at the end of the month ranged from a few inches to more than a foot in depth.

A severe cold wave overspread the upper Yukon and Copper River districts from the 15th to 20th, with minimum temperatures from 10° to 24° below zero.

Brilliant auroras were noted in the upper Yukon on the 1st and 15th.

Average temperatures and departures from the normal.

Districts.	Number of stations.	Average temperatures for the current month.	Departures for the current month.	Accumulated departures since January 1.	Average departures since January 1.
		°	°	°	°
New England	12	47.1	− 3.6	−23.6	− 2.4
Middle Atlantic	16	52.4	− 3.7	−15.6	− 1.6
South Atlantic	10	61.5	− 2.2	+ 5.4	+ 0.5
Florida Peninsula*	8	73.0	− 0.9	+11.5	+ 1.2
East Gulf	11	65.6	+ 0.1	+16.1	+ 1.6
West Gulf	10	67.5	+ 1.2	+20.4	+ 2.0
Ohio Valley and Tennessee	13	54.5	− 2.5	− 5.3	− 0.5
Lower Lake	10	47.3	− 4.2	−22.1	− 2.2
Upper Lake	12	45.2	− 2.4	−15.6	− 1.6
North Dakota*	9	44.5	+ 1.6	−25.8	− 2.6
Upper Mississippi Valley	15	51.5	− 1.3	−10.2	− 1.0
Missouri Valley	12	53.6	+ 0.9	− 2.4	− 0.2
Northern Slope	9	49.2	+ 4.8	− 7.5	− 0.8
Middle Slope	6	56.8	+ 1.2	+11.5	+ 1.2
Southern Slope*	7	62.4	0.0	+19.2	+ 1.9
Southern Plateau*	12	58.0	+ 0.8	+ 0.9	+ 0.1
Middle Plateau*	10	53.7	+ 5.1	+10.1	+ 1.0
Northern Plateau*	12	53.4	+ 5.3	− 3.0	− 0.3
North Pacific	7	53.6	+ 2.5	− 1.7	− 0.2
Middle Pacific	8	61.5	+ 1.9	− 2.0	− 0.2
South Pacific	4	64.2	+ 1.9	+ 4.6	+ 0.5

* Regular Weather Bureau and selected cooperative stations.

In Canada.—Director R. F. Stupart says:

The temperature was supernormal from eastern Saskatchewan to the coast of British Columbia, and normal in southern Manitoba, and very locally along the Gulf of St. Lawrence; elsewhere in Canada it was subnormal. Positive departures from the average were pronounced in Alberta, varying between 5° and 9°, while negative differences of from 2° to 5° were recorded in Ontario and the greater portion of Quebec.

The precipitation of the month differed materially over the various portions of the Dominion, in fact more so than usually occurs. From Manitoba to the Pacific coast it was deficient to the extent of from 66 to 100 per cent, whereas from eastern Ontario to the Gulf of St. Lawrence there was a marked excess over the average, the equivalent being 16 per cent in the Ottawa Valley, increasing to the large amount of 102 per cent in the Gaspe Peninsula. In Ontario, over the greater portion of the Province, the precipitation varied considerably with the district, some localities recording a positive departure and others a negative. In the Maritime Provinces the departures from the average were unimportant, except in Cape Breton where a considerable excess was experienced.

Average precipitation and departures from the normal.

Districts.	Number of stations.	Average.		Departure.	
		Current month.	Percentage of normal.	Current month.	Accumulated since Jan. 1.
		Inches.		Inches.	Inches.
New England	12	3.57	100	0.0	− 3.1
Middle Atlantic	16	2.30	70	−1.0	− 3.3
South Atlantic	10	0.65	18	−3.0	−11.4
Florida Peninsula*	8	2.47	49	−2.6	− 8.8
East Gulf	11	1.11	40	−1.7	− 3.7
West Gulf	10	3.52	125	+0.7	− 8.0
Ohio Valley and Tennessee	13	2.38	92	−0.2	− 2.0
Lower Lake	10	3.66	124	+0.7	− 0.8
Upper Lake	12	1.44	51	−1.4	− 1.9
North Dakota*	9	0.77	66	−0.4	− 1.2
Upper Mississippi Valley	15	1.31	54	−1.1	+ 2.0
Missouri Valley	12	1.68	89	−0.2	− 2.4
Northern Slope	9	0.25	38	−0.4	+ 0.9
Middle Slope	6	2.46	158	+0.9	− 1.2
Southern Slope*	7	3.80	173	+1.6	− 0.4
Southern Plateau*	12	2.70	300	+1.8	+ 3.8
Middle Plateau*	10	1.16	100	0.0	+ 2.2
Northern Plateau*	12	0.74	65	−0.4	+ 1.6
North Pacific	7	1.26	32	−2.7	− 9.9
Middle Pacific	8	1.33	93	−0.1	+ 2.8
South Pacific	4	1.80	225	+1.0	+ 2.5

* Regular Weather Bureau and selected cooperative stations.

Average relative humidity and departures from the normal.

Districts.	Average.	Departure from the normal.	Districts.	Average.	Departure from the normal.
	%			%	
New England	73	− 6	Missouri Valley	62	− 9
Middle Atlantic	74	− 2	Northern Slope	67	+ 7
South Atlantic	74	− 4	Middle Slope	68	+ 9
Florida Peninsula	75	− 5	Southern Slope	76	+13
East Gulf	73	0	Southern Plateau	64	+18
West Gulf	77	+ 5	Middle Plateau	61	+12
Ohio Valley and Tennessee	74	+ 3	Northern Plateau	60	− 3
Lower Lake	73	− 1	North Pacific	86	− 4
Upper Lake	77	− 1	Middle Pacific	72	+ 2
North Dakota	70	− 2	South Pacific	74	+ 4
Upper Mississippi Valley	73	− 1			

Average cloudiness and departures from the normal.

Districts.	Average.	Departure from the normal.	Districts.	Average.	Departure from the normal.
New England	4.8	− 0.7	Missouri Valley	3.4	− 0.5
Middle Atlantic	3.6	− 1.2	Northern Slope	2.8	− 1.4
South Atlantic	3.3	− 0.7	Middle Slope	4.2	+ 1.1
Florida Peninsula	3.2	− 1.5	Southern Slope	6.1	+ 3.3
East Gulf	4.4	+ 0.8	Southern Plateau	4.4	+ 2.4
West Gulf	5.1	+ 1.5	Middle Plateau	4.6	+ 1.4
Ohio Valley and Tennessee	4.6	+ 0.1	Northern Plateau	3.1	− 2.0
Lower Lake	5.6	− 0.2	North Pacific	6.9	+ 1.0
Upper Lake	5.8	− 0.3	Middle Pacific	5.1	+ 1.9
North Dakota	3.6	− 1.5	South Pacific	4.4	+ 1.4
Upper Mississippi Valley	4.2	− 0.2			

Maximum wind velocities.

Stations.	Date.	Velocity.	Direction.	Stations.	Date.	Velocity.	Direction.
Block Island, R. I.	8	54	nw.	New York, N. Y.	29	50	nw.
Do	29	51	nw.	North Head, Wash.	28	52	se.
Buffalo, N. Y.	11	50	sw.	Do	30	60	se.
Eastport, Me.	8	53	s.	Point Reyes Light, Cal.	1	78	nw.
Galveston, Tex.	30	62	nw.	Do	2	52	n.
Mount Tamalpais, Cal.	1	62	nw.	Portland, Me.	8	52	s.
Do	2	54	n.	Tatoosh Island, Wash.	10	50	ne.
Do	3	50	n.	Williston, N. Dak.	8	55	nw.
Nantucket, Mass.	8	60	sw.				

CLIMATOLOGICAL SUMMARY.

By Mr. JAMES BERRY, Chief of the Climatological Division.

TEMPERATURE AND PRECIPITATION BY SECTIONS, OCTOBER, 1907.

In the following table are given, for the various sections of the Climatological Service of the Weather Bureau, the average temperature and rainfall, the stations reporting the highest and lowest temperatures with dates of occurrence, the stations reporting greatest and least monthly precipitation, and other data, as indicated by the several headings.

The mean temperatures for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperature and precipitation are based only on records from stations that have ten or more years of observation. Of course the number of such records is smaller than the total number of stations.

Section.	Temperature—in degrees Fahrenheit.								Precipitation—in inches and hundredths.					
	Section average.	Departure from the normal.	Monthly extremes.						Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest.	Date.			Station.	Amount.	Station.	Amount.
Alabama	63.4	− 0.5	Decatur	95	2	Riverton	26	28	1.44	− 1.16	Lucy	3.50	Letohatchie	0.10
Arizona	64.4	− 0.1	Aztec	106	4	Flagstaff	23	1	2.42	+ 1.61	Grand Canyon	8.48	Fort Huachuca	0.33
Arkansas	61.9	0.0	Hope Lewisville	96 96	2 2	Bergman Dutton	23 23	13 13	3.03	+ 0.57	Mena	10.85	Dodd City	0.14
California	62.0	+ 1.6	Mammoth Tank	107	11	Summit Tamarack	21 21	1 3	1.56	− 0.14	Pine Crest	6.91	Elmwood	0.02
Colorado	49.1	+ 3.1	Holly Lamar	91 91	7 6	San Luis Wagonwheel Gap	12 12	19 30	0.87	− 0.20	Santa Clara	2.38	Fort Morgan	0.00
Florida	71.4	− 1.5	Orange City	97	9	Galt, Molino	32	29	1.57	− 2.73	Jupiter	5.65	Wausau	0.00
Georgia	62.6	− 1.6	Millen	94	8	Point Peter Toccoa	29 29	29 29	0.86	− 1.83	Butler	4.13	Experiment	0.04
Hawaii	73.9†	......	Kihei, Maui Waialua, Oahu	91 91	2, 26 4	Waimea, Hawaii	44	22	6.28‡	......	Hakalau (Mauka), Hawaii	26.17	Kekaha, Kauai	0.06
Idaho	52.3	+ 4.8	Orofino	92	5	Forney	16	3	0.96	− 0.42	Landore	2.79	Poplars	0.20
Illinois	52.8	− 1.8	3 stations	89	2	Lanark	17	28	1.65	− 0.62	Cobden	4.22	La Harpe	0.30
Indiana	51.6	− 3.0	Rome	89	3	Northfield	19	29	2.74	+ 0.29	Bloomington	4.80	Delphi	1.31
Iowa	50.4	− 2.1	3 stations	85	2, 17	Audubon, Massena	10	28	1.50	− 0.89	Boone	3.71	Tipton	0.30
Kansas	57.3	0.0	Coolidge Toronto	93 93	6 2	Frankfort	20	28	3.13	+ 1.36	Toronto	7.80	Plainville	0.11
Kentucky	55.5	− 2.6	Greensburg	93	1	Shelby City	20	29	2.97	+ 0.78	Taylorsville	4.66	West Liberty	0.34
Louisiana	68.3	+ 1.0	Monroe	98	2	Robeline	29	14	4.27	+ 1.66	Jennings	14.26	St. Francisville	0.25
Maryland and Delaware	51.2	− 4.2	Great Falls, Md Westernport, Md	83 83	3 3	Deer Park, Md	15	24	2.41	− 0.72	Newark, Del	4.23	Green Sp'g Fur., Md.	1.03
Michigan	45.0	− 3.9	Port Austin	84	3	3 stations	10	26–28	1.69	− 1.13	Mackinac Island	5.60	Mount Pleasant	0.20
Minnesota	45.4	− 0.9	Taylors Falls	88	5	Taylors Falls	9	28	1.31	− 1.14	Blackduck	2.83	Beaulieu	0.39
Mississippi	64.6	+ 0.1	3 stations	94	2–4	Duck Hill Quitman	29 29	29 29	2.16	+ 0.01	Water Valley	5.08	Biloxi	0.44
Missouri	56.7	− 0.7	Mount Vernon	94	2	3 stations	18	27, 28	2.90	+ 0.45	Lamar	6.44	2 stations	0.99
Montana	49.1	+ 4.1	Lewistown	89	11	Fallon	9	27	0.35	− 0.46	Norris	1.27	8 stations	0.00
Nebraska	52.7	+ 1.6	Gothenburg	95	6	Hay Springs	9	27	0.63	− 0.97	Superior	4.04	10 stations	0.00
Nevada	54.2	+ 4.9	Logan	96	4	Dyer	13	28	0.98	+ 0.43	Palmetto	6.93	3 stations	0.00
New England*	45.3	− 3.8	Torrington, Conn	76	5	Van Buren, Me	10	21	4.66	+ 0.70	So. Egremont, Mass.	10.51	Hyannis, Mass	1.92
New Jersey	50.6	− 4.3	Bridgeton	80	3, 7	River Vale	18	25	4.46	+ 0.45	Dover	7.18	Toms River	2.70
New Mexico	54.6	+ 0.4	Glen	94	2	Elizabethtown	18	30	1.88	+ 0.70	Carlsbad	8.08	Valley	T.
New York	45.7	− 4.0	South Canisteo	85	3	Indian Lake	10	31	4.43	+ 1.27	Carmel	9.43	Chazy	2.06
North Carolina	56.7	− 3.0	Kinston	93	5	Buck Spring	14	29	0.92	− 2.53	Horse Cove	2.19	Southern Pines	0.15
North Dakota	44.4	+ 1.8	Kulm	88	6	3 stations	4	18, 27	0.70	− 0.37	Larimore	2.27	3 stations	0.00
Ohio	48.8	− 4.6	3 stations	88	2, 3	Bladensburg Millport	19 19	24 26	2.76	+ 0.59	Hillhouse	6.93	Milfordton	0.95
Oklahoma and Indian Territories.	61.7	− 0.3	Ardmore, Durant, I. T	95	1	Kenton, Okla	23	8	4.56	+ 2.36	Durant, Ind. T	10.96	Kenton, Okla	0.50
Oregon	55.6	+ 4.2	Fairview	95	4	Yonna	18	2	1.21	− 1.87	Port Orford	3.92	Huntington	0.01
Pennsylvania	48.2	− 3.7	St. Marys	87	3	Pocono Lake	13	31	3.16	− 0.16	Point Pleasant	5.64	Everett	1.01
Porto Rico	77.7	......	Central Aguirre	97	19	Aibonito	54	24	9.69	......	Lares	19.85	Central Aguirre	3.64
South Carolina	61.2	− 2.3	Walterboro	91	7	Aiken	28	29	0.73	− 2.40	Beaufort	2.32	Aiken	0.00
South Dakota	48.4	+ 0.2	3 stations	89	6	Kidder	9	18	0.74	− 0.80	Kidder	2.55	6 stations	T.
Tennessee	57.5	− 1.6	Dover	93	2	Rugby	21	29	2.50	− 0.07	Memphis	4.90	Knoxville	0.93
Texas	67.1	+ 0.6	Encinal	101	1	Miami	24	9	5.35	+ 3.00	Alvin	13.00	Brownsville	0.78
Utah	52.5	+ 4.8	St. George	90	12	Coyoto	17	3	1.45	+ 0.57	Ranch	3.41	Thistle	0.20
Virginia	53.2	− 3.8	Dinwiddie	89	3	Burkes Garden	16	15	1.43	− 1.85	Warsaw	3.13	Buchanan	0.50
Washington	54.5	+ 3.5	Zindel	94	5	Colville	21	11	0.80	− 1.54	Quiniault	3.89	Ephrata	0.00
West Virginia	50.3	− 4.6	Doane	87	3	Bayard	19	24	2.65	+ 0.45	Webster Springs	5.12	Harpers Ferry	0.54
Wisconsin	45.8	− 3.0	Brodhead Racine	82 82	2 2	Hayward	10	28	0.78	− 2.00	Lake Mills	1.57	Brodhead	0.16
Wyoming	46.5	+ 4.0	Wyncote	84	5	Dubois Soda Butte, Y. N. P.	10 10	3 d'ts 9	0.35	− 0.66	Fayette	1.74	4 stations	0.00

* Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut. † 48 stations, with an average elevation of 531 feet. ‡ 140 stations.

DESCRIPTION OF TABLES AND CHARTS.

By Mr. P. C. DAY, Assistant Chief, Division of Meteorological Records.

For description of tables and charts see page 30 of REVIEW for January, 1907.

TABLE I.—*Climatological data for U. S. Weather Bureau stations, October, 1907.*

Stations.	Elevation of instruments: Barometer above sea level, feet.	Elevation of instruments: Thermometers above ground.	Elevation of instruments: Anemometer above ground.	Pressure, in inches: Actual, reduced to mean of 24 hours.	Pressure, in inches: Sea level, reduced to mean of 24 hrs.	Pressure, in inches: Departure from normal.	Temperature of the air, in degrees Fahrenheit: Mean max. + mean min. ÷ 2.	Temperature: Departure from normal.	Temperature: Maximum.	Temperature: Date.	Temperature: Mean maximum.	Temperature: Minimum.	Temperature: Date.	Temperature: Mean minimum.	Temperature: Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity, per cent.	Precipitation, in inches: Total.	Precipitation: Departure from normal.	Precipitation: Days with .01, or more.	Wind: Total movement, miles.	Wind: Prevailing direction.	Wind: Maximum velocity: Miles per hour.	Wind: Maximum velocity: Direction.	Wind: Maximum velocity: Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness during daylight, tenths.	Total snowfall.
New England.							47.1	-3.6										73	3.57	0.0										4.8	
Eastport	76	69	85	29.88	29.96	-.04	44.6	-2.0	65	17	51	26	22	38	25	41	37	76	4.71	+0.9	10	9,084	nw.	53	s.	8	6	9	16	6.9	0.9
Portland, Me.	103	81	117	29.89	30.01	-.03	46.0	-3.1	65	18	53	27	27	39	26	41	36	71	2.53	-1.1	8	7,553	nw.	52	s.	8	15	9	7	4.4	
Concord	288	70	79	29.69	30.01	-.04	44.6	-4.1	72	17	56	19	27	33	38	...	...	...	3.74	+0.5	11	4,190	nw.	27	w.	8	18	5	8	3.9	
Burlington	404	12	47	29.57	30.02	-.02	43.1	-6.5	69	4	51	22	31	35	27	...	...	...	3.59	+0.4	14	8,409	s.	41	s.	10	6	7	18	7.2	1.5
Northfield	876	16	70	29.08	30.04	.00	40.7	-2.9	69	4	51	18	27	30	35	38	36	86	5.14	+2.7	12	6,556	s.	42	nw.	30	5	11	15	6.7	1.9
Boston	125	115	188	29.90	30.03	-.02	49.8	-2.5	74	17	58	32	21	42	28	44	39	68	2.54	-1.3	5	7,996	nw.	35	sw.	8	14	9	8	4.4	
Nantucket	12	14	90	30.02	30.03	-.02	50.5	-4.0	66	12	56	34	27	44	22	47	43	76	1.99	-1.4	7	12,495	sw.	60	sw.	8	15	10	6	4.6	
Block Island	26	11	46	30.02	30.05	.00	50.8	-4.5	68	8	56	35	31	45	22	46	41	70	2.19	-1.9	4	13,521	nw.	54	nw.	8	16	9	6	3.4	
Narragansett	...	9	...	...	...	...	47.7	-4.4	68	5	58	22	31	37	32	...	...	...	2.70	...	5	...	w.	...	...	...	23	4	4	...	
Providence	160	57	67	29.87	30.05	.00	49.0	-3.2	72	17	59	27	27	39	31	44	39	72	2.44	-0.4	6	4,891	nw.	27	sw.	9	18	8	5	3.5	
Hartford	159	122	132	29.87	30.05	-.01	48.6	-2.6	72	4	59	25	27	39	32	43	38	71	4.53	+0.7	7	5,375	nw.	40	s.	8	14	8	9	4.8	
New Haven	106	116	155	29.94	30.06	.00	49.8	-3.0	73	4	60	28	27	40	30	45	40	72	4.85	+0.9	7	7,396	nw.	48	s.	8	19	8	4	3.2	
Mid. Atlantic States.							52.4	-3.7										74	2.30	-1.0										3.6	
Albany	97	102	115	29.95	30.06	.00	47.6	-2.8	74	4	57	28	31	38	29	42	38	77	3.71	+0.7	11	5,812	s.	33	s.	8	13	11	7	4.5	0.1
Binghamton	871	78	90	29.12	30.07	+.01	45.8	-3.4	78	3	56	23	31	36	36	...	...	...	3.33	+0.2	10	4,595	nw.	31	s.	27	9	11	11	5.5	1.0
New York	314	108	350	29.72	30.06	.00	52.5	-2.1	73	7	60	36	31	45	28	46	41	68	3.82	+0.1	9	9,227	nw.	50	nw.	29	18	9	4	3.1	
Harrisburg	374	94	104	29.70	30.11	+.03	50.6	-3.6	74	3	60	31	31	42	32	44	39	70	1.54	-1.4	7	4,871	nw.	33	nw.	8	20	8	3	3.4	
Philadelphia	117	116	184	29.97	30.10	+.03	54.1	-2.2	76	3	62	36	31	46	25	47	42	69	3.38	+0.3	7	8,069	nw.	38	s.	8	18	9	4	3.5	
Scranton	805	111	119	29.21	30.08	+.01	47.9	-3.5	79	3	58	26	31	38	33	42	38	76	2.88	0.0	8	5,258	sw.	36	nw.	8	10	15	6	5.1	
Atlantic City	52	37	48	30.04	30.10	+.03	52.3	-5.1	73	18	60	33	31	44	25	47	42	70	3.19	-0.1	7	6,602	nw.	32	s.	28	21	5	5	2.7	
Cape May	17	48	52	30.10	30.12	+.05	53.1	-6.5	70	18	60	32	31	47	24	49	...	...	3.19	-0.1	7	7,339	n.	34	nw.	29	26	1	4	2.7	
Baltimore	123	69	117	29.96	30.10	+.02	53.2	-4.3	79	3	63	33	31	44	30	47	42	70	1.61	-1.4	7	4,907	nw.	30	w.	8	18	8	5	3.2	
Washington	112	89	76	29.99	30.11	+.03	52.0	-4.6	81	3	63	30	31	41	35	45	41	76	2.12	-1.0	8	5,273	nw.	38	nw.	28	18	9	4	3.4	
Cape Henry	18	11	58	30.09	30.11	+.04	58.4	-3.7	82	3	66	40	25	50	27	...	...	...	0.82	-3.1	5	11,645	n.	46	nw.	8	23	3	5	3.0	
Lynchburg	681	83	88	29.39	30.14	+.05	53.9	-3.0	84	3	66	30	25	42	46	47	43	77	0.60	-2.8	4	2,562	nw.	30	nw.	28	20	7	4	3.5	
Mount Weather	1,725	10	57	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Norfolk	91	102	111	30.03	30.13	+.06	57.6	-3.7	80	3	66	37	25	49	81	51	46	71	1.19	-2.7	3	6,476	n.	30	w.	28	21	3	7	3.3	
Richmond	144	145	153	29.99	30.14	+.06	55.9	-3.9	84	3	67	34	25	45	37	...	...	...	2.30	-1.0	4	6,042	n.	37	w.	8	19	7	5	3.1	
Wytheville	2,293	40	47	27.75	30.16	+.07	50.5	-3.1	79	3	62	26	15	39	38	44	42	86	0.85	-2.3	8	3,548	w.	25	nw.	28	16	7	8	3.9	T.
S. Atlantic States.							61.5	-2.2										74	0.65	-3.0										3.3	
Asheville	2,255	53	75	27.79	30.17	+.08	52.8	-2.5	77	2	65	27	15	41	36	46	42	76	0.50	-2.4	4	4,593	nw.	34	nw.	29	16	9	6	3.8	
Charlotte	773	68	76	29.31	30.15	+.07	58.4	-2.7	79	3	68	34	29	48	28	50	44	65	0.81	-2.3	2	4,543	n.	24	nw.	28	19	5	7	3.7	
Hatteras	11	12	47	30.10	30.11	+.05	62.0	-4.0	82	8	68	46	25	56	20	58	56	85	0.40	-5.6	2	11,542	ne.	42	nw.	28	21	9	1	2.7	
Raleigh	376	71	79	29.73	30.14	+.07	58.0	-2.5	81	3	69	36	22	47	34	50	44	67	0.22	-3.3	4	4,395	nw.	30	nw.	28	21	4	6	3.1	
Wilmington	78	81	91	30.04	30.13	+.07	60.6	-2.7	85	8	71	38	29	50	28	53	49	72	0.27	-3.5	6	5,486	ne.	30	nw.	28	20	10	1	2.3	
Charleston	48	14	92	30.07	30.12	+.06	65.0	-2.1	87	8	73	43	29	58	23	58	55	75	1.53	-2.4	4	7,804	n.	36	ne.	21	20	7	4	3.0	
Columbia, S. C.	351	41	57	29.75	30.14	+.07	61.4	-2.6	84	5	73	35	29	50	32	53	47	67	0.40	-2.4	3	4,693	n.	30	sw.	27	14	12	5	4.5	
Augusta	·180	89	97	29.93	30.13	+.06	62.6	-1.0	85	5	74	35	29	51	34	55	51	77	0.52	-1.8	4	3,809	nw.	26	sw.	27	15	11	5	3.5	
Savannah	65	81	89	30.05	30.12	+.07	65.6	-0.7	88	8	74	41	29	57	24	58	55	77	0.46	-3.1	3	5,044	n.	26	n.	8	21	5	5	3.1	
Jacksonville	43	101	129	30.05	30.10	+.08	68.3	-1.3	87	5	76	46	29	60	26	63	60	83	1.37	-3.7	5	6,214	ne.	26	ne.	16	19	8	4	3.6	
Florida Peninsula.							76.0	-0.1										75	2.96	-2.8										3.2	
Jupiter	28	10	48	29.99	30.02	+.06	76.4	-0.4	90	5	83	60	14	70	19	70	67	76	5.65	-3.8	14	8,869	ne.	36	ne.	14	7	22	2	5.0	
Key West	22	10	53	29.98	29.99	+.05	78.7	0.0	89	8	84	69	30	74	15	71	69	74	2.10	-3.3	6	6,705	ne.	22	ne.	14	18	10	3	3.1	
Sand Key	25	41	71	29.96	29.99	+.05	79.0	...	92	9	83	70	30	75	16	...	...	...	3.04	-2.4	5	11,069	ne.	43	ne.	15	17	12	2	3.4	
Tampa	35	79	96	30.03	30.06	+.08	72.8	+0.2	88	1	82	51	29	64	24	65	61	75	1.07	-1.9	6	5,954	ne.	26	ne.	15	26	5	0	1.5	
East Gulf States.							65.6	+0.1										73	1.11	-1.7										4.4	
Atlanta	1,174	190	216	28.90	30.14	+.07	61.8	-0.6	80	3	71	36	29	53	30	52	45	62	1.22	-1.1	6	6,901	nw.	30	nw.	28	18	4	9	4.0	
Macon	370	55	66	29.74	30.14	+.08	63.4	-0.3	87	7	76	36	29	51	38	...	...	...	0.38	-1.7	2	2,854	nw.	14	w.	5	17	8	6	3.4	
Thomasville	273	8	58	29.82	30.11	+.07	66.4	-1.6	90	8	79	38	29	54	37	58	55	80	0.15	-3.3	2	3,335	n.	17	sw.	8	19	9	3	3.2	
Pensacola	56	79	96	30.05	30.11	+.08	69.5	+0.1	85	1	77	48	13	62	20	...	...	...	0.83	-3.2	5	6,227	n.	23	n.	28	13	8	10	4.4	
Anniston	741	9	58	29.36	30.16	+.09	61.0	-1.4	86	2	74	32	29	48	37	...	...	...	0.80	-1.5	5	3,539	se.	22	se.	31	16	4	11	4.7	
Birmingham	700	136	144	29.37	30.14	+.07	63.2	-1.2	85	2	73	36	29	53	30	56	53	75	0.95	-1.4	5	4,571	n.	23	n.	28	10	14	7	4.9	
Mobile	57	98	106	30.04	30.10	+.06	69.5	+2.4	87	1	78	45	29	61	25	62	58	74	0.82	-2.4	5	4,522	n.	25	nw.	28	12	12	7	4.7	
Montgomery	223	100	112	29.88	30.14	+.08	65.4	-0.3	87	1	76	39	14	55	34	57	52	71	1.14	-1.3	4	3,923	e.	20	n.	13	13	11	7	4.4	
Meridian	375	84	93	29.72	30.12	+.06	64.0	+1.0	88	4	76	35	29	52	35	56	53	77	0.82	-1.9	7	2,868	ne.	18	w.	7	17	5	9	4.3	
Vicksburg	247	62	74	29.85	30.13	+.07	66.6	+1.3	88	3	76	42	13	58	27	58	54	71	3.46	+0.7	7	3,840	ne.	36	w.	7	13	8	10	4.6	
New Orleans	51	88	121	30.04	30.09	+.06	71.2	+1.7	89	3	78	48	14	64	20	64	60	77	1.61	-1.3	8	5,684	ne.	25	sw.	7	9	9	13	5.9	
West Gulf States.							67.5	+1.2										77	3.52	+0.7										5.1	
Shreveport	249	77	84	29.85	30.12	+.07	66.9	+1.3	91	7	76	42	14	58	31	59	54	73	3.19	0.0	11	3,943	ne.	30	se.	2	12	10	9	4.7	
Bentonville	1,303	11	44	28.75	30.12	+.07	59.4	+1.4	86	2	72	28	13	47	37	...	...	...	2.26	-0.6	7	3,250	n.	22	e.	1	17	5	9	4.4	
Fort Smith	457	79	94	29.63	30.12	+.07	62.4	+0.7	87	2	74	35	28	51	31	54	49	73	2.22	-0.6	6	4,541	e.	25	n.	7	14	11	6	4.2	
Little Rock	357	139	147	29.75	30.13	+.07	63.3	+0.4	87	1	73	38	14	54	31	56	51	72	3.25	+0.7	5	4,602	ne.	27	w.	7	16	8	7	4.1	
Corpus Christi	20	48	53	30.01	30.03	+.03	75.4	+2.8	89	7	80	61	11	70	21	70	68	82	0.81	-1.2	7	8,147	ne.	29	se.	29	8	18	5	5.0	
Fort Worth	670	106	114	29.38	30.09	+.06	66.2	-0.1	95	1	74	47	13	58	30	...	...	...	3.01	+0.5	11	5,507	se.	30	nw.	7	8	17	6	5.2	
Galveston	54	106	112	30.02	30.08	+.05	73.6	+1.2	87	1	78	60	15	70	14	68	66	81	6.96	+2.8	12	8,679	ne.	62	nw.	30	15	7	9	4.6	
Palestine	510	73	79	29.56	30.09	+.06	66.8	+0.6	90	7	74	44	15	59	28	60	58	82	5.32	+1.7	14	4,507	ne.	20	ne.	12	8	5	18	6.7	
San Antonio	701	80	91	29.32	30.04	+.03	71.8	+2.6	94	2	80	53	15	63	33	64	60	76	3.54	+2.0	10	5,619	ne.	26	nw.	7	7	10	14	6.2	
Taylor	583	55	63	29.46	30.07	+.05	69.0	+0.7	96	1	77	49	14	61	34	...	...	...	4.63	+2.1	14	5,814	n.	26	se.	3	6	12	13	6.2	
Ohio Val. and Tenn.							54.5	-2.5										74	2.32	-0.2										4.6	
Chattanooga	762	106	112	29.35	30.17	+.08	59.6	-1.2	83	3	71	35	15	48	33	52	47	72	1.16	-1.7	8	3,810	nw.	28	nw.	27	17	6	8	4.0	
Knoxville	1,004	93	100	29.09	30.16	+.07	56.6	-1.5	81	3	68	32	29	46	31	50	46	76	0.93	-1.7	5	3,048	ne.	22	sw.	7	14	8	9	4.7	
Memphis	399	76	97	29.73	30,16	+.09	62.6	+0.1	85	2	71	37	28	54	26	55	51	72	4.90	+2.2	5	4,718	n.	27	sw.	3	21	2	8	3.3	
Nashville	546	79	91	29.58	30.17	+.09	59.2	-1.1	86	2	71	33	29	47	37	50	46	71	2.01	-0.5	5	3,228	w.	21	sw.	7	14	8	9	4.4	
Lexington	989	75	102	29.09	30.16	+.08	53.4	-3.1	83	3	63	30	29	44	30	...	...	...	2.76	+0.5	7	6,972	sw.	32	nw.	8	14	3	14	5.0	
Louisville	525	111	132	29.57	30.16	+.08	55.9	-2.5	86	3	66	30	29	45	34	48	43	69	2.96	+0.3	7	5,348	sw.	29	w.	11	14	8	9	4.7	T.
Evansville	431	72	82	29.66	30.13	+.05	56.6	-1.4	81	3	67	34	28	46	32	...	...	...	2.05	-1.0	5	4,338	s.	23	s.	3	13	12	6	4.1	
Indianapolis	822	154	164	29.24	30.14	+.07	51.9	-3.1	83	2	61	31	28	43	29	46	41	72	2.23	-0.6	5	6,732	s.	26	nw.	27	9	11	11	5.5	
Cincinnati	628	152	160	29.47	30.16	+.08	53.6	-3.4	84	2	64	31	29	44	31	46	41	68	2.86	+0.5	7	4,770	sw.	24	sw.	11	15	10	6	4.5	
Columbus	824	173	224	29.25	30.14	+.06	50.0	-4.1	82	3	60	29	29	40	32	44	39	72	1.59	-0.8	7	8,232	nw.	42	nw.	27	14	8	9	4.6	T.
Pittsburg	842	336	352	29.21	30.13	+.05	50.0	-4.9	79	3	59	31	24	41	33	44	39	71	1.64	-0.7	9	6,902	nw.	42	w.	11	14	8	9	4.8	T.
Parkersburg	638	77	84	29.48	30.15	+.07	51.6	-3.0	83	3	63	31	22	40	37	45	41	79	2.11	-0.3	10	3,864	n.	26	nw.	28	12	13	6	4.7	T.
Elkins	1,940	41	50	28.08	30.18	+.08	47.8	-3.6	80	3	60	26	22	35	42	41	39	88	3.73	+1.3	11	2,438	w.	20	w.	20	6	14	11	5.9	T.
Lower Lake Region.							47.3	-4.2										73	3.66	+0.7										5.6	
Buffalo	767	178	206	29.23	30.08	+.03	47.8	-3.7	75	3	55	28	31	41	28	42	38	73	4.86	+1.3	11	10,875	nw.	50	sw.	11	7	17	7	5.7	T.
Canton	448	10	71	29.53	30.01	...	42.6	-4.6	70	7	52	19	21	33	32	...	...	...	3.02	-0.3	14	7,752	sw.	44	sw.	22	8	9	14	6.1	T.
Oswego	335	76	91	29.67	30.05	.00	46.4	-4.8	73	7	54	27	31	39	29	42	38	75	5.81	+2.5	15	8,134	s.	31	n.	29	7	10	14	6.3	T.
Rochester	523	81	102	29.50	30.08	+.03	47.4	-3.4	75	3	55	28	21	39	37	41	37	74	3.21	+0.4	14	6,147	sw.	25	nw.	8	9	11	11	5.8	
Syracuse	597	97	113	29.41	30.06	.00	46.1	-4.9	74	3	54	25	21	39	31	...	...	...	3.40	+0.2	15	9,081	s.	48	s.	27	9	6	16	5.9	T.
Erie	713	92	102	29.31	30.09	+.04	49.0	-4.1	80	3	56	33	31	42	30	43	37	68	4.29	+0.5	11	8,048	nw.	35	s.	27	11	8	12	5.5	
Cleveland	762	190	201	29.28	30.11	+.05	48.6	-4.5	80	2	56	32	24	41	32	44	38	69	4.13	+1.4	12	12,021	s.	45	nw.	7	6	16	9	5.4	T.
Sandusky	629	62	70	29.43	30.12	+.06	49.0	-4.9	81	2	56	30	29	42	30	...	...	...	3.43	+1.0	10	6,188	sw.	32	n.	8	13	7	11	4.9	
Toledo	628	207	246	29.43	30.12	+.07	48.8	-3.8	81	2	57	29	29	40	30	44	40	76	2.60	+0.3	8	9,680	sw.	39	sw.	10	14	8	9	4.7	
Detroit	730	218	258	29.31	30.11	+.06	47.3	-3.4	76	2	55	29	26	39	26	43	40	78	1.86	-0.5	10	9,662	nw.	40	sw.	7	12	7	12	5.4	T.
Upper Lake Region.							45.2	-2.4										77	1.44	-1.4										5.8	
Alpena	609	13	92	29.40	30.07	+.04	42.8	-3.1	75	2	52	21	21	33	34	39	36	83	1.69	-1.7	9	7,406	nw.	32	nw.	17	7	13	11	6.0	T.
Escanaba	612	40	82	29.41	30.09	+.08	43.0	-2.1	76	17	51	22	26	35	39	39	35	76	0.88	-2.2	9	7,759	sw.	34	n.	7	10	10	11	5.7	T.
Grand Haven	682	54	92	29.40	30.10	+.07	46.4	-3.9	72	3	55	25	26	38	29	43	39	77	1.41	-1.1	10	8,471	n.	36	w.	9	7	10	14	6.0	

TABLE I.—*Climatological data for U. S. Weather Bureau stations, October, 1907*—Continued.

Stations.	Elevation of instruments.			Pressure, in inches.			Temperature of the air, in degrees Fahrenheit.									Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity, per cent.	Precipitation, in inches.			Wind.					Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness during daylight, tenths.	Total snowfall.
	Barometer above sea level, feet.	Thermometers above ground.	Anemometer above ground.	Actual, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hrs.	Departure from normal.	Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.				Total.	Departure from normal.	Days with .01, or more.	Total movement, miles.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.					
Up. Lake Reg—Cont.																															
Grand Rapids	707	121	162	29.33	30.11	+ .07	46.8	− 3.3	76	2	56	26	26	38	26	42	38	78	1.44	− 1.1	8	7,338	n.	40	sw.	6	8	8	15	6.1	
Houghton	668	66	74	29.32	30.06	+ .06	43.2	− 2.9	71	16	51	25	26	35	31	...	...	...	1.80	− 1.4	12	4,798	w.	24	ne.	24	7	12	12	5.8	T.
Marquette	734	77	116	29.26	30.08	+ .07	44.1	− 1.6	72	17	51	27	28	37	34	38	33	72	2.35	− 0.8	10	8,416	nw.	38	sw.	21	8	10	13	5.9	1.0
Port Huron	638	70	120	29.39	30.09	+ .05	45.7	− 3.8	75	2	54	26	21	37	28	41	38	80	1.92	− 0.8	9	8,510	sw.	34	nw.	7	6	14	11	5.8	
Sault Ste. Marie	614	40	61	29.37	30.08	+ .07	40.7	− 2.7	67	17	48	22	30	33	28	37	35	83	2.33	− 0.9	10	6,860	nw.	38	nw.	22	5	6	20	7.4	T.
Chicago	823	140	310	29.22	30.12	+ .08	52.6	− 0.6	81	2	59	35	28	46	29	47	44	77	0.93	− 1.6	8	10,842	sw.	41	w.	9	10	10	11	5.3	
Milwaukee	681	122	139	29.37	30.12	+ .09	48.8	− 1.4	79	2	56	31	28	42	25	43	39	73	0.78	− 1.6	9	7,684	w.	34	sw.	6	13	10	8	4.8	T.
Green Bay	617	49	86	29.40	30.07	+ .05	46.4	− 0.7	76	6	55	24	28	38	32	41	36	75	0.82	− 1.6	7	7,365	sw.	39	n.	7	10	8	13	6.1	T.
Duluth	1,133	11	47	28.82	30.06	+ .06	42.6	− 2.6	70	16	51	23	18	35	29	37	32	74	0.95	− 1.8	9	10,849	nw.	46	nw.	10	12	10	9	4.9	T.
North Dakota.							**44.2**	**+ 1.7**										**70**	**0.78**	**− 0.7**										**3.6**	
Moorhead	940	8	57	29.04	30.08	+ .08	44.4	+ 1.6	79	16	57	15	18	32	43	38	35	79	1.60	− 0.5	5	6,363	nw.	28	nw.	10	13	9	9	4.3	
Bismarck	1,674	8	57	28.30	30.12	+ .13	45.2	+ 1.1	87	5	60	14	27	30	51	36	30	68	0.80	− 0.2	4	6,875	nw.	46	nw.	8	23	4	4	2.8	1.2
Devils Lake	1,482	11	44	28.44	30.04	+ .05	42.6	+ 2.1	83	5	56	13	25	29	43	35	30	73	0.63	− 1.4	6	7,919	s.	45	n.	17	17	7	7	3.6	0.6
Williston	1,875	14	56	28.05	30.07	+ .09	44.8	+ 1.9	82	5	62	12	25	27	47	34	26	60	0.08	− 0.7	1	7,115	nw.	55	nw.	8	17	7	7	3.8	
Upper Miss. Valley.							**51.5**	**− 1.3**										**73**	**1.31**	**− 1.1**										**4.2**	
Minneapolis	.....	102	208	.....	.....	.....	47.9	.....	77	6	58	26	28	38	31	...	...	...	1.26	− 1.3	7	9,357	s.	42	nw.	27	17	7	7	3.8	
St. Paul	837	171	179	29.16	30.08	+ .07	47.2	− 0.9	76	6	57	24	28	38	32	41	35	67	0.96	− 1.4	6	7,560	se.	40	n.	27	12	10	9	5.1	
La Crosse	714	71	87	29.31	30.09	+ .07	48.2	− 1.7	77	6	58	22	28	38	29	...	...	...	0.57	− 1.9	9	5,719	s.	28	n.	27	11	6	14	5.5	T.
Madison	974	70	78	29.04	30.10	+ .07	47.4	− 1.4	77	2	55	24	28	39	29	42	38	75	1.14	− 1.3	11	7,042	sw.	29	sw.	6	13	7	11	4.9	
Charles City	1,015	8	58	29.02	30.12	+ .10	46.8	− 1.4	79	2	59	17	28	34	37	41	38	80	0.64	− 1.4	4	5,279	s.	24	nw.	7	15	7	9	4.6	
Davenport	606	71	79	29.45	30.12	+ .08	51.7	− 0.9	84	2	61	24	28	42	31	45	40	72	0.70	− 1.7	4	5,010	nw.	25	se.	1	18	6	7	3.6	
Des Moines	861	84	101	29.20	30.12	+ .09	51.6	− 0.9	78	17	63	22	28	40	36	44	39	70	1.70	− 1.0	6	5,623	sw.	30	sw.	6	12	12	7	4.6	T.
Dubuque	698	100	117	29.36	30.13	+ .09	49.5	− 2.5	81	2	59	24	28	40	29	44	40	76	0.77	− 1.9	7	4,613	nw.	24	nw.	27	16	4	11	4.2	
Keokuk	614	64	77	29.45	30.14	+ .09	54.0	− 0.5	84	2	64	25	28	44	37	46	42	75	0.47	− 2.0	5	4,921	nw.	30	w.	9	21	5	5	3.3	
Cairo	356	87	93	29.76	30.15	+ .08	58.4	− 0.7	87	2	68	34	28	49	31	51	47	74	2.90	+ 0.3	7	5,028	s.	32	n.	27	16	6	9	3.7	
La Salle	536	56	64	29.56	30.14	+ .10	50.9	− 1.0	83	2	61	26	28	41	37	...	...	...	0.87	− 1.7	7	5,195	sw.	30	w.	9	14	7	10	4.7	
Peoria	609	11	45	29.46	30.14	+ .09	51.4	− 0.6	84	2	62	22	28	40	37	45	41	76	0.35	− 2.2	5	5,542	s.	32	w.	9	20	4	7	3.3	
Springfield, Ill.	644	10	92	29.44	30.13	+ .08	53.8	− 0.8	84	2	64	27	28	43	37	47	42	72	1.36	− 1.2	4	6,333	s.	29	nw.	27	18	6	7	3.5	
Hannibal	534	75	109	29.55	30.12	+ .07	53.8	− 2.1	82	2	64	24	28	43	37	...	...	...	2.74	+ 1.1	8	6,071	sw.	29	w.	10	20	2	9	3.8	
St. Louis	567	208	217	29.51	30.12	+ .06	56.0	− 2.4	82	1	65	31	28	47	29	50	44	69	3.15	+ 0.7	8	7,320	s.	30	nw.	27	15	8	8	4.2	
Missouri Valley.							**53.6**	**+ 0.9**										**62**	**1.68**	**− 0.2**										**3.4**	
Columbia, Mo.	784	11	84	29.29	30.12	+ .07	54.7	− 0.1	82	2	66	23	28	43	39	...	...	...	2.16	− 0.3	7	4,951	se.	25	nw.	27	18	4	9	4.0	
Kansas City	963	116	181	29.11	30.16	+ .12	56.9	+ 1.1	80	2	66	33	28	47	30	49	43	66	2.25	0.0	7	8,394	s.	36	n.	7	18	6	7	3.5	
Springfield, Mo	1,324	98	104	28.72	30.13	+ .08	57.8	+ 0.5	88	2	68	33	28	48	28	51	46	72	2.63	− 0.2	10	6,230	se.	24	n.	7	19	3	9	3.7	
Iola	984	40	47	29.07	30.13	+ .09	57.6	+ 0.7	88	2	69	29	28	47	37	...	...	...	5.04	+ 2.8	9	4,559	sw.	25	n.	7	14	9	8	4.7	
Topeka	.....	85	89	.....	.....	.....	56.8	+ 0.5	84	2	68	29	13	46	34	...	...	...	2.54	+ 0.6	9	5,609	s.	39	w.	2	17	6	8	3.7	
Lincoln	1,189	11	84	28.82	30.10	+ .07	54.2	+ 0.9	82	6	67	26	13	42	37	45	38	64	1.60	− 0.2	4	7,225	s.	33	n.	7	20	5	6	2.8	
Omaha	1,105	115	121	28.92	30.11	+ .08	54.3	+ 0.1	80	6	65	31	12	44	35	45	38	60	2.09	− 0.3	5	6,256	s.	38	n.	7	21	3	7	3.1	
Valentine	2,598	47	54	27.36	30.10	+ .09	50.6	+ 2.1	83	6	67	19	27	34	44	40	31	56	0.30	− 1.0	1	7,186	s.	36	n.	6	28	8	0	2.2	
Sioux City	1,135	96	164	28.88	30.10	+ .08	50.8	− 0.3	82	2	63	21	13	38	43	...	...	...	0.62	− 1.2	5	9,478	se.	40	n.	7	20	4	7	3.2	
Pierre	1,572	70	75	28.41	30.09	+ .08	51.2	+ 2.1	87	6	65	23	27	38	44	40	30	53	0.56	− 0.2	3	6,284	se.	43	n.	6	19	9	3	3.0	
Huron	1,306	56	67	28.68	30.11	+ .10	47.0	+ 2.3	86	6	63	18	25	31	51	38	30	62	0.36	− 1.0	2	8,212	nw.	36	n.	17	17	10	4	3.6	
Yankton	1,233	49	57	28.76	30.09	+ .08	51.2	+ 0.7	82	16	65	23	13	37	47	...	...	...	0.04	− 1.5	1	5,785	nw.	30	se.	1	18	5	8	3.7	
Northern Slope.							**49.2**	**+ 4.8**										**67**	**0.25**	**− 0.4**										**2.8**	
Havre	2,505	11	44	27.39	30.03	+ .05	49.6	+ 6.0	83	5	67	20	18	32	48	42	37	70	0.05	− 0.4	1	5,210	e.	35	nw.	7	26	5	0	2.4	
Miles City	2,371	26	48	27.54	30.12	+ .12	51.5	+ 5.0	86	5	68	22	27	35	46	42	37	69	0.22	− 0.6	2	3,503	ne.	24	nw.	8	26	4	1	1.9	
Helena	4,110	8	56	25.89	30.09	+ .06	49.8	+ 5.8	77	5	62	30	18	38	36	41	34	61	0.58	− 0.2	3	3,801	sw.	27	w.	4	21	7	3	2.7	
Kalispell	2,962	8	34	27.00	30.07	+ .06	48.8	+ 6.3	71	5	63	28	31	35	35	42	38	77	T.	− 1.2	0	2,995	w.	20	sw.	31	22	6	3	2.5	
Rapid City	3,234	46	50	.....	.....	.....	.....	.....	...	...	...	...	...	...	...	...	...	...	.....	.....	...	.....	.....	...	.....	...	...	...	...	...	
Cheyenne	6,088	56	64	24.10	30.10	+ .09	48.0	+ 2.7	76	5	62	25	20	34	41	39	33	63	0.08	− 0.6	3	5,899	nw.	33	w.	1	18	8	5	3.3	
Lander	5,372	26	36	24.74	30.13	+ .09	48.1	+ 6.0	76	5	64	25	29	32	41	39	32	63	0.40	− 0.6	3	1,800	sw.	20	ne.	2	20	9	2	3.0	
Sheridan	3,790	5	...	26.18	30.12	.00	48.4	......	81	5	66	23	27	31	47	...	...	...	0.29	......	3	......	se.	...	......	...	18	8	5	3.4	
Yellowstone Park	6,200	11	48	23.98	30.13	+ .11	45.0	+ 3.5	69	12	58	25	3	32	39	36	30	66	0.54	− 0.6	6	4,093	sw.	27	w.	27	12	12	7	4.2	0.7
North Platte	2,821	11	51	27.18	30.13	+ .11	52.8	− 2.8	88	6	70	26	18	36	46	42	36	70	0.14	− 1.0	1	4,911	w.	30	ne.	6	24	6	1	1.6	
Middle Slope.							**56.8**	**+ 1.2**										**68**	**2.46**	**+ 0.9**										**4.2**	
Denver	5,291	129	136	24.83	30.09	+ .08	53.4	+ 2.4	81	5	67	31	26	40	42	43	35	56	0.17	− 0.8	3	4,989	s.	36	n.	6	19	9	3	3.5	
Pueblo	4,685	80	86	25.38	30.07	+ .08	54.1	+ 1.7	83	6	69	31	21	39	45	43	34	54	1.53	+ 0.8	3	4,516	nw.	44	n.	6	21	8	2	2.9	
Concordia	1,398	42	50	28.64	30.12	+ .09	55.8	+ 0.4	87	2	68	30	13	44	35	48	44	74	3.17	+ 1.2	5	4,491	s.	28	se.	2	14	12	5	3.7	
Dodge	2,509	44	54	29.49	30.10	+ .08	57.2	+ 2.5	88	2	70	33	8	44	39	48	44	73	2.36	+ 1.0	6	6,169	se.	36	ne.	18	7	18	6	5.2	
Wichita	1,358	78	86	28.70	30.13	+ .10	58.6	+ 0.2	88	2	69	35	28	48	33	51	46	73	4.10	+ 1.8	7	5,085	s.	33	ne.	7	15	9	7	4.5	
Oklahoma	1,214	10	47	28.82	30.10	+ .07	61.5	+ 0.2	88	2	72	38	28	51	38	54	50	77	3.42	+ 1.6	6	8,849	s.	41	n.	7	10	10	11	5.5	
Southern Slope.							**63.2**	**+ 0.8**										**76**	**3.69**	**+ 1.9**										**6.1**	
Abilene	1,738	45	54	28.28	30.08	+ .07	65.2	+ 1.0	92	2	74	44	9	57	32	58	54	76	3.92	+ 1.6	11	4,849	se.	30	nw.	7	6	11	14	6.6	
Amarillo	3,676	10	49	26.35	30.06	+ .06	57.6	+ 1.5	86	2	69	35	8	46	37	50	46	76	1.79	+ 0.1	10	8,196	s.	43	n.	7	10	12	9	5.4	
Del Rio	944	8	57	29.03	30.01	+ .03	71.2	+ 1.3	95	2	80	47	11	62	36	...	...	...	6.09	+ 4.6	12	5,506	se.	28	se.	3	5	12	14	6.9	
Roswell	3,578	9	57	26.41	30.03	+ .07	59.0	− 0.5	87	2	71	34	11	47	44	51	47	75	2.98	+ 1.5	10	3,457	s.	35	nw.	7	8	12	11	5.6	
Southern Plateau.							**60.4**	**+ 0.5**										**64**	**2.28**	**+ 1.4**										**4.4**	
El Paso	3,762	10	110	26.22	29.96	+ .04	63.5	+ 1.1	88	2	74	42	11	52	39	52	45	62	2.52	+ 1.6	8	6,575	e.	33	ne.	3	11	12	8	4.9	
Santa Fe	7,013	33	39	23.33	30.02	+ .06	50.8	+ 0.8	71	11	62	33	30	39	33	42	36	67	1.12	+ 0.1	8	5,678	ne.	30	e.	3	17	11	3	3.5	
Flagstaff	6,907	8	57	23.39	29.95	+ .03	46.6	+ 1.9	70	12	58	23	1	35	39	41	37	79	4.58	+ 2.7	14	4,456	n.	28	sw.	2	10	8	13	6.0	0.2
Phoenix	1,108	50	56	28.75	29.89	+ .01	70.7	+ 0.5	98	11	83	49	3	59	45	58	40	45	4.00	+ 1.6	9	2,691	e.	24	nw.	17	10	17	4	4.5	
Yuma	141	16	46	29.73	29.87	.00	72.7	+ 0.3	102	11	86	53	29	59	39	60	53	59	1.32	+ 1.1	3	3,122	ne.	28	ne.	23	22	4	5	2.6	
Independence	3,910	11	42	26.00	29.98	+ .03	57.8	− 1.5	79	10	68	38	29	48	29	48	41	63	2.12	+ 1.4	7	4,916	se.	28	n.	2	16	2	13	4.7	
Middle Plateau.							**53.9**	**+ 3.9**										**61**	**1.27**	**+ 0.3**										**4.6**	
Reno	4,532	56	63	25.48	29.98	− .01	53.8	+ 4.1	79	7	67	30	3	41	42	45	39	64	1.74	+ 1.3	9	2,727	w.	24	nw.	1	13	11	7	4.4	
Tonopah	6,089	12	20	24.11	30.03	.....	52.4	+ 4.0	72	7	60	30	2	45	31	44	36	59	1.23	+ 0.4	7	6,569	se.	34	nw.	3	9	16	6	4.8	
Winnemucca	4,344	18	56	25.64	30.02	− .03	54.0	+ 5.4	81	11	70	29	29	38	45	44	37	61	0.60	+ 0.1	3	3,874	ne.	18	nw.	1	19	6	6	3.4	
Modena	5,479	10	43	24.65	29.98	+ .02	51.2	+ 1.1	75	11	63	29	29	39	36	44	38	68	1.71	+ 0.9	12	6,015	w.	44	n.	2	7	10	14	6.5	
Salt Lake City	4,366	105	110	25.66	30.01	.00	57.4	+ 5.2	78	12	68	40	29	47	26	48	40	56	1.16	− 0.2	9	3,775	se.	30	e.	13	18	6	7	3.8	
Durango	6,546	18	56	23.73	30.02	+ .05	50.6	+ 1.7	76	4	65	28	1	36	41	40	33	62	0.99	− 0.8	5	3,960	nw.	23	w.	6	4	20	7	5.8	
Grand Junction	4,608	43	51	25.44	30.01	+ .02	58.1	+ 4.8	79	5	70	37	29	46	33	47	39	56	1.48	+ 0.3	4	3,009	e.	18	se.	30	17	9	5	3.4	
Northern Plateau.							**56.2**	**+ 6.8**										**60**	**0.64**	**− 0.6**										**3.1**	
Baker City	3,471	48	58	26.49	30.07	− .01	53.8	+ 8.3	78	4	68	31	3	40	40	45	38	60	0.44	− 0.5	5	4,704	s.	18	nw.	2	20	8	3	2.7	
Boise	2,739	78	86	27.20	30.06	.00	57.8	+ 7.5	81	5	70	33	3	46	35	49	41	57	1.16	− 0.1	7	3,181	n.	24	ne.	12	15	8	8	4.0	
Lewiston	757	10	51	29.24	30.05	− .02	58.2	+ 6.4	90	5	72	38	2	44	41	...	...	...	0.48	− 0.7	3	2,118	se.	33	w.	6	18	8	5	3.1	
Pocatello	4,477	46	54	25.55	30.07	+ .03	55.2	+ 5.5	79	5	67	33	3	43	40	44	36	60	0.84	− 0.1	8	3,961	se.	26	sw.	12	18	11	2	2.9	
Spokane	1,929	101	110	28.02	30.07	+ .01	55.8	+ 6.5	80	5	68	32	9	40	40	46	40	62	0.25	− 1.3	3	2,487	ne.	22	s.	1	16	13	2	3.5	
Walla Walla †	1,000	71	79	28.97	30.04	− .03	60.4	+ 6.7	86	5	71	44	31	49	31	50	42	55	0.70	− 0.8	2	3,028	s.	16	sw.	7	23	5	3	2.6	
N. Pac. Coast Reg.							**53.6**	**+ 2.6**										**86**	**1.26**	**− 2.7**										**6.9**	
North Head	211	11	56	29.81	30.04	− .01	54.4	+ 1.5	80	10	58	46	16	51	28	52	50	90	0.90	− 3.0	11	9,074	se.	60	se.	30	7	8	16	6.9	
Port Crescent	259	12	29	29.79	30.07	− .05	49.1	+ 1.7	67	10	57	31	18	42	32	...	...	...	0.88	− 2.6	9	3,343	se.	15	sw.	23	9	4	18	6.1	
Seattle	123	185	224	29.96	30.07	+ .04	53.2	+ 2.4	70	10	58	43	18	48	24	51	50	89	0.67	− 2.2	7	4,070	n.	29	s.	31	4	10	17	7.7	
Tacoma	213	113	120	29.84	30.07	+ .03	52.8	+ 2.8	70	4	58	42	19	48	28	...	...	...	1.17	− 2.2	8	2,951	n.	28	n.	29	3	5	23	8.3	
Tatoosh Island	86	7	57	29.94	30.04	+ .03	50.8	+ 0.9	66	10	55	42	18	47	16	49	48	92	3.40	− 4.6	13	9,989	ne.	50	ne.	10	6	1	24	7.8	
Portland, Oreg.	153	68	106	29.87	30.03	− .03	57.3	+ 4.0	80	10	64	44	17	50	29	54	51	82	0.93	− 2.8	6	3,506	nw.	21	sw.	31	5	14	12	6.0	
Roseburg	510	9	57	29.48	30.02	− .06	57.7	+ 4.9	82	4	68	41	14	48	36	54	51	79	0.89	− 1.7	9	1,464	n.	12	sw.	1	13	11	7	4.5	

TABLE I.—*Climatological data for U. S. Weather Bureau stations, October, 1907*—Continued.

Stations.	Elevation of instruments. Barometer above sea level, feet.	Thermometers above ground.	Anemometer above ground.	Pressure, in inches. Actual, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hrs.	Departure from normal.	Temperature of the air, in degrees Fahrenheit. Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity, per cent.	Precipitation, in inches. Total.	Departure from normal.	Days with .01, or more.	Wind. Total movement, miles.	Prevailing direction.	Maximum velocity. Miles per hour.	Direction.	Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness during daylight, tenths.	Total snowfall.
Mid. Pac. Coast Reg.							61.5	+ 1.9										72	1.33	— 0.1										5.1	
Eureka	62	62	80	29.95	30.02	— .04	55.2	+ 2.1	70	4	59	45	2	52	19	53	51	88	1.48	— 1.2	10	2,962	n.	35	n.	2	3	9	19	7.3	
Mount Tamalpais	2,375	11	18	27.53	30.00	— .01	57.5	......	82	4	64	44	31	51	22	50	44	68	1.65	+ 0.4	7	11,288	nw.	62	nw.	1	17	5	9	3.9	
Point Reyes Light	490	7	18	29.44	29.95	......	56.6	......	79	4	61	47	15	52	26	...	...	...	1.62	......	6	12,152	nw.	78	nw.	1	9	7	15	6.4	
Red Bluff	332	50	56	29.50	29.94	— .09	66.6	+ 2.8	95	4	79	49	27	55	35	54	47	57	0.90	— 0.7	4	3,256	se.	27	nw.	2	15	7	9	4.2	
Sacramento	69	106	117	29.88	29.95	— .04	64.3	+ 2.1	91	4	75	45	19	54	34	56	51	67	1.20	+ 0.2	4	5,261	s.	29	nw.	2	18	6	7	3.4	
San Francisco	155	200	204	29.81	29.98	— .03	60.6	+ 2.2	90	4	67	51	13	54	31	54	51	79	1.36	+ 0.1	7	4,886	w.	28	sw.	7	10	10	11	4.8	
San Jose	141	78	88	29.82	29.98	......	60.8	+ 0.5	91	4	72	42	13	50	44	...	...	...	0.98	— 0.3	5	......	nw.	...	......	...	15	7	9	4.3	
Southeast Farallon	30	9	17	29.95	29.98	......	57.1	......	71	4	60	50	15	54	18	...	...	...	1.74	+ 0.5	7	8,670	nw.	48	nw.	1	8	7	16	6.6	
S. Pac. Coast Reg.							64.2	+ 1.9										74	1.30	+ 1.0										4.4	
Fresno	330	67	70	29.60	29.95	— .01	64.8	+ 0.1	90	10	77	47	2	53	37	55	48	62	1.08	+ 0.4	4	3,078	nw.	18	w.	1	19	2	10	3.8	
Los Angeles	338	116	123	29.58	29.94	— .01	65.6	+ 3.3	87	3	75	48	13	57	32	58	55	78	1.19	+ 0.4	8	3,336	w.	22	ne.	3	12	4	15	5.4	
San Diego	87	94	102	29.84	29.93	— .02	64.9	+ 1.9	78	15	70	54	3	60	20	60	58	82	1.71	+ 1.2	9	3,945	w.	21	nw.	7	19	8	4	3.7	
San Luis Obispo	201	47	54	29.76	29.97	— .02	61.6	+ 2.4	90	4	73	44	14	50	43	54	50	75	3.23	+ 1.9	4	3,264	nw.	18	w.	2	13	8	10	4.9	
West Indies.																															
Grand Turk	11	6	20	29.93	29.94	......	81.0	......	91	*	87	69	*	75	...	...	...	...	7.21	......	16	......	......	...	......	...	...	...	...	...	
San Juan	82	48	90	29.83	29.91	+ .01	80.0	......	92	13	86	70	3	74	16	75	73	81	5.12	—1.1	19	5,617	s.	38	ne.	7	9	12	10	5.3	
Panama.																															
Ancon	74	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Bas Obispo	40	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Naos	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Christobal	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	

* More than one date. † Record incomplete.

TABLE II.—*Climatological record of cooperative observers, October, 1907.*

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Alabama.	°	°	°	*Ins.*	*Ins.*
Ashville	86	31	61.1	1.38	
Auburn	83	39	64.2	1.90	
Bermuda	87	35	65.2	1.25	
Boligee	91	32	64.4	1.60	
Bridgeport	......	......	......	2.15	
Calera	......	......	......	1.72	
Camphill	87	36ᵉ	62.4	0.65	
Cedar Bluff	......	......	......	1.27	
Citronelle	89	37	68.5	0.63	
Clanton	88	32	63.0	1.17	
Cordova	89	29	61.6	1.62	
Cullinan	89	32	61.4	1.77	
Decatur	95	33	61.4	1.96	
Demopolis	......	......	......	0.76	
Eufaula	82	37	61.8	0.63	
Evergreen	90	39	67.4	0.92	
Flomaton	90	35	67.2	0.85	
Florence	90	31	60.8	1.91	
Fort Deposit	88	39	65.2	1.57	
Gadsden	87	34	61.9	1.50	
Good Water	88	40	64.2	0.81	
Greensboro	87	37	65.6	1.50	
Guntersville	......	......	......	1.88	
Hamilton	90	30	62.7	2.09	
Highland Home	89	39	67.0	2.52	
Letohatchee	......	......	......	0.10	
Livingston	88	31	63.1	1.03	
Lock No. 4	87	32	61.7	0.62	
Lucy	89	34	65.4	3.50	
Madison Station	88	32	60.6	2.04	
Maplegrove	86	30	59.3	1.17	
Newbern	92	34	66.4	1.37	
Oneonto	85	29	59.8	1.77	
Opelika	85	37	64.0	1.59	
Ozark	87	38	65.8	1.13	
Prattville	88ᶠ	33ᶠ	63.8ᶠ	1.86	
Pushmataha	90	33	64.4	1.73	
Riverton	90	26	59.6	2.12	
Scottsboro	84	31	59.1	1.61	
Selma	91	35	65.0	1.98	
Spring Hill	87	44	68.3	1.60	
Talladega	88	33	63.6	1.29	
Tallassee	......	......	......	1.01	
Thomasville	87	37	63.8	0.49	
Tuscaloosa	90	33	62.4	1.54	
Tuscumbia	88	31	59.0	1.16	
Tuskegee	92	36	67.3	0.88	
Union Springs	87	38	64.4	0.63	
Valley Head	86	27	58.9	2.25	
Vienna	......	......	......	1.66	
Wetumpka	90	34	66.8	0.73	
Alaska.					
Copper Center	52	—20	26.8	......	......
Chestochena	62	—18	28.0	1.34	6.0
Fairbanks	......	......	......	1.73	17.3
Juneau	54	24	45.4	11.19	3.0
Alaska—Cont'd.	°	°	°	*Ins.*	*Ins.*
Ketchumstock	......	......	......	0.72	9.0
Killisnoo	57	27	43.5	8.57	1.2
Orca	......	......	......	29.15	
Sitka	62	27	46.9	11.77	
Skagway	56	20	43.0	5.87	T.
Tonsina	60	—22	30.1	1.07	8.0
Arizona.					
Allaire Ranch	......	......	......	1.83	
Arizona Canal Co. Dam	98	49	72.1	2.07	
Aztec	106	43	74.0	0.96	
Benson	89	38	64.4	0.60	
Bisbee	81	41	60.4	0.96	
Bonita	......	......	......	1.48	
Bowie	89	39	63.8	1.50	
Buckeye	101	43	70.4	1.46	
Casa Grande	95	45	71.0	0.80	
Chiarsons Mill	64	28	43.8	13.29	
Clifton	......	......	......	3.33	
Cline	93	42	65.2	3.46	
Cochise *1	84	48	66.6	1.92	
Columbia	98	54	70.4	2.81	
Congress	91	52	66.8	2.43	
Douglas	91	38	64.8	0.63	
Dudleyville	92	44	66.1	1.75	
Fish Creek	......	......	......	1.81	
Flagstaff	73	26	49.0	5.47	
Fort Apache	82	31	57.2	3.77	
Fort Huachuca	82	34	60.8	0.33	
Fort Mojave	104	51	74.0	2.60	
Fredonia	79	28	55.0	1.20	
Gila Bend	101	55	75.0	1.95	
Globe	88	40	64.0	4.19	
Grand Canyon	72	26	49.4	8.48	
Greer	......	......	......	3.24	
Holbrook	81	33	56.6	3.44	
Huachuca Reservoir	......	......	......	2.84	
Intake	......	......	......	2.76	
Jerome	80	42	59.7	5.40	
Keams Canyon	76	29	52.8	1.93	
Kingman	94	37	63.6	3.11	
Maricopa	102	45	70.8	1.47	
Mesa	102	47	71.2	1.91	
Mohawk Summit	98	60	78.0	1.50	
Natural Bridge	......	......	......	6.79	
Paradise	......	......	......	3.71	
Parker	102	47	73.4	0.61	
Phoenix (Ex. Farm)	99	44	69.8	1.85	
Picacho *5	98	60	75.1	0.65	
Pinal Ranch	......	......	......	3.93	
Pinto	......	......	......	2.92	
Prescott	78	40	58.1	2.76	
Roosevelt	90	36	60.9	2.70	
St. Johns	82	27	53.0	1.62	
St. Michaels	......	26	......	2.10	
San Carlos	97	36	66.5	3.60	
San Simon	88	31	60.2	1.01	
Arizona—Cont'd.	°	°	°	*Ins.*	*Ins.*
Seligman	78	31	54.9	1.90	
Sentinel	100	50	69.0	1.08	
Silverbell	92	51	68.6	1.05	
Tempe	106	43	71.3	2.36	
Thatcher	85	35	63.8	4.04	
Tombstone	81	44	62.6	0.70	
Tucson	96	42	69.6	1.13	
Vail *5	92	60	74.9	0.86	
Walnut Grove	......	......	......	1.80	
Willcox	84	34	60.1	2.24	
Williams	82	28	55.2	2.70	
Yarnell	......	......	......	3.47	
Arkansas.					
Alicia	87	29	59.2	2.40	
Amity	91	31	61.9	2.72	
Arkadelphia	93	34	66.0	3.71	
Arkansas City	......	......	......	2.32	
Batesville	91	31	62.2	2.28	
Bee Branch	89	33	63.0	2.90	
Benton	91	33	63.6	2.27	
Bergman	90	23	57.6	1.41	
Brinkley	92	31	61.8	5.56	
Camden	90	33	63.7	3.11	
Center Point	93	33	64.4	3.32	
Clarendon	......	......	......	4.32	
Conway	90	33	61.4	3.80	
Dardanelle	......	......	......	2.28	
Des Arc	91	32	61.7	5.22	
Dodd City	90	25	59.3	1.40	
Dutton	89	23	59.3	2.49	
Earl	91	30	62.0	2.92	
El Dorado	94	35	65.4	3.34	
England	90ᵍ	32	64.2ᵈ	3.39	
Eureka Springs	88	29	59.4	1.97	
Fayetteville	88	28	60.8	2.22	
Forrest City	89	33	60.8	4.19	
Fulton	......	......	......	4.18	
Hardy	89	30	60.4	2.85	
Helena	89	35	62.8	2.87	
Hope	96	34	66.0	3.84	
Hot Springs	88	31	61.4	3.36	
Jonesboro	......	......	......	3.32	
Junction	92	33	63.6	2.95	
La Crosse	91	31	61.2	2.15	
Lewisvilleᶜ	96	34	66.6	......	
Lutherville	89	28	61.0	2.46	
Luxora	......	......	......	2.70	
Malvern	88	32	59.6	2.80	
Mammoth Spring	90	27	58.6	2.65	
Marvell	90	33	63.8	2.91	
Mena	85	36	62.2	10.85	
Montrose	95ᵉ	33ᵈ	64.4ᵉ	2.45	
Mossville	83	30	58.6	1.70	
Mount Nebo	81	39	63.8	4.44	
Newport	89	33	61.4	2.80	
Ozark	90ᵈ	33ᵉ	64.0ʲ	2.11	

TABLE II.—*Climatological record of cooperative observers*—Continued.

Stations.	Temperature. (Fahrenheit.)			Precipitation.	
	Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.
Arkansas—Cont'd.	°	°	°	*Ins.*	*Ins.*
Pine Bluff	92	33	62.6	2.57	
Pocahontas	90	33	61.0	5.73	
Pond	86	25	58.8	2.38	
Prescott	94	32	63.9	2.10	
Princeton	91	29	64.0	1.55	
Rogers	89	27	59.6	1.26	
Russellville	89	31	60.0	3.77	
Spielerville	90	34	63.4	1.83	
Stuttgart	91	30	62.6	2.66	
Texarkana	85[i]	41[m]	64.3[i]	......	
Warren	94	31	63.6	2.34	
Wiggs	89	27	61.2	3.29	
California.					
Alturas	85	26	54.0	1.90	
Auburn	86	46	65.4	1.04	
Azusa	90	43	63.6	2.19	
Bagdad	95	55	73.6	1.86	
Barstow	92	40	63.6	3.39	
Bear Valley	......	......	......	2.47	
Berkeley	87	48	60.4	1.54	
Bishop	80[f]	35[f]	57.1[f]	1.81	
Blocksburg	94	37	60.1	1.60	
Blue Canyon	84	33	56.0	1.61	
Branscomb	88	35	57.8	1.52	
Brush Creek	88	36	57.4	1.47	
Butte Valley	......	......	......	1.55	
Calexico	99	54	73.0	0.80	
Campbell	90	38	59.4	1.17	
Campo	......	......	......	2.46	
Cedarville	82	25	54.2	1.36	
Chico	96	49	67.9	0.97	
Claremont	94	47	66.0	1.82	
Cloverdale	99	41	62.0	1.02	
Colfax	78	42	61.3	0.58	
Colusa	91	37	61.0	0.51	
Crescent City	75	43	56.4	2.03	
Crockers	......	......	......	2.00	
Cuyamaca	70	35	49.8	3.40	
Delta	93	37	61.9	2.11	
Dobbins	98	44	67.9	0.45	
Durham	95	41	64.9	0.47	
El Cajon	92	45	66.6	2.10	
Electra	90[d]	45[d]	66.2[d]	0.78	
Elmwood	89	41	63.0	0.02	
Elsinore	90	38	61.8	2.99	
Emigrant Gap	75	25	49.4	3.85	
Escondido	92	39	60.8	1.98	
Folsom	96	44	63.4	0.40	
Fordyce	......	......	......	2.49	
Fort Ross	80	46	59.4	1.92	
Georgetown	87	39	60.6	1.48	
Gold Run	90	40	62.3	1.01	
Greenville	83	28	54.6	1.61	
Healdsburg	103[e]	39[e]	62.6[e]	1.10	
Heber	105	51	74.3	1.14	
Hollister	93	38	60.2	1.24	
Idyllwild	81	30	51.8	4.55	
Indio	101	56	74.5	1.60	
Iowa Hill	87	41	61.0	1.22	
Isabella	......	......	......	1.13	
Jolon	......	......	......	2.98	
Kennedy Gold Mine	......	......	......	1.04	
Kentfield	......	......	......	2.01	
Kernville	......	......	......	1.98	
King City	98	42	59.9	......	
LaPorte	74	30	52.4	1.65	
Le Grande	86	43	65.0	0.67	
Lemoncove	95	42	67.2	0.70	
Lick Observatory	76	37	54.5	1.62	
Livermore	93	39	63.3	0.81	
Lodi	86	40	61.8	0.40	
Lone Pine	81	35	57.7	2.71	
Los Gatos	90	42	57.9	1.41	
Lowe Observatory	......	......	......	3.36	
Magalia	92	38	59.4	1.55	
Mammoth	107	55	75.2	0.52	
Marysville	98	47	65.9	2.25	
Merced	88	40	63.0	0.29	
Mill Creek	86	40	65.9	1.24	
Mills College	......	......	......	1.43	
Milo	......	......	......	1.73	
Mojave	85	60	73.6	1.20	
Mokelumne Hill	85	43	62.9	0.94	
Mono Ranch	79	37	55.2	5.27	
Montague	86	23	53.6	0.31	
Monterio	84	40	59.1	3.60	
Monumental	84	33	56.0	3.30	
Mount St. Helena	......	......	......	0.95	
Napa	99	44	63.4	0.62	
Nevada City	92	29	58.6	0.79	
Newcastle	91	44	65.0	1.08	
Newman	88[d]	41[d]	64.6[d]	1.01	
Nimshew	90	34	60.8	1.14	
North Bloomfield	87	33	56.2	0.96	
Oakland	85	48	60.8	1.62	
Ojai Valley	92	42	64.0	3.38	
Orland	95	46	67.2	0.83	
Orleans	102	42	67.4	1.83	
California—Cont'd.	°	°	°	*Ins.*	*Ins.*
Oroville (near)	96	45	66.4	0.44	
Ozena	......	......	......	2.83	
Palermo	96	41	66.0	0.32	
Pilot Creek	......	......	......	1.54	
Pine Crest	86	53	64.8	6.92	
Placerville	82	33	58.0	0.91	
Point Lobos	77	54	61.3	1.17	
Porterville	93	41	66.2	1.48	
Poway	87	40	65.8	1.66	
Quincy	83	27	55.1	1.90	
Redding	94	47	66.2	2.17	
Redlands	96	46	65.6	3.37	
Reedley	90	40	64.0	0.44	
Represa	......	......	......	0.39	
Rialto	96	48	67.4	4.51	
Riverside	95[f]	46[f]	65.1[f]	......	
Rocklin	90	42	65.4	0.74	
Rohnerville	76	39	57.9	1.60	
Sacramento	82	44	61.7	1.27	
Salinas	89	39	59.5	1.64	
San Bernardino	97	42	65.7	2.75	
San Miguel Island	......	......	......	2.89	
Santa Barbara	87	47	63.1	6.23	
Santa Clara College	92	38	60.8	1.16	
Santa Cruz	88	40	60.0	3.00	
Santa Maria	85	45	61.2	3.57	
Santa Monica	91	44	60.7	1.79	
Santa Rosa	93	38	60.4	0.87	
Shasta	102	40	70.0	2.40	
Sierra Madre	88	50	64.8	3.47	
Sisson	87	34	56.8	0.77	
Stirling City	91	30	57.4	2.05	
Stockton	84	43	62.4	0.54	
Storey	88	39	62.4	0.06	
Summerdale	78	33	53.4	3.16	
Summit	68	21	38.5	2.52	3.0
Susanville	78	28	52.5	1.99	
Tamarack	66	21	43.2	1.57	3.5
Towle	83	35	56.5	1.73	
Truckee	68	28	49.8	1.36	
Tulare	88	40	62.9	1.44	
Tustin (near)	......	......	......	1.24	
Ukiah	98	34	61.1	0.69	
Upper Lake	91	38	61.8	1.02	
Upper Mattole	......	......	......	1.43	
Vacaville	96	37	65.4	0.67	
Wasco	96	30	56.7	0.80	
Westpoint	......	......	......	1.14	
West Saticoy	......	......	......	4.57	
Wheatland	92	42	64.8	0.75	
Willits	82	30	53.2	1.20	
Willows	94	43	64.8	0.43	
Woodleaf	......	......	......	4.83	
Woodside	76	42	58.3	1.88	
Yosemite	84	31	54.7	1.73	
Colorado.					
Akron	......	......	......	0.02	
Amethyst	76	16	43.3	1.10	1.2
Arriba	83	25	51.4	T.	
Ashcroft	68	18	41.6	1.35	4.0
Blaine	89	28	55.0	0.20	
Boulder	81	34	54.2	0.58	
Breckenridge	67	16	40.9	0.35	T.
Buena Vista	65	24	42.3	1.13	T.
Canyon	83	38	53.3	0.75	
Cascade	......	......	......	2.14	
Castle Rock	76[e]	23[e]	47.6[e]	0.70	
Cheesman	80	29	50.0	0.88	T.
Cheyenne Wells	89	30	54.3	0.35	
Chromo	74	18	45.7	1.13	
Collbran	81[e]	23[e]	52.2[e]	1.68	
Colorado Springs	75	28	50.4	0.69	
Cope	86	22	54.2	0.28	
Corona	48	19	32.2	1.17	7.0
Cripple Creek	......	......	......	0.70	0.2
Delta	85	29	55.8	0.96	
Dunkley	70	19	44.9	1.21	T.
Eads	85	28	54.5	0.40	
Eagle	79	18	47.8	0.62	
Eureka	......	......	......	1.03	4.0
Fort Collins	82	22	49.9	0.08	
Fort Morgan	82	26	51.8	0.00	
Frances	66	26	44.4	1.54	7.0
Fruita	82	28	55.6	1.83	
Garnett	74[l]	17	47.2[f]	0.63	
Gladstone	......	......	......	1.09	5.3
Gleneyre	81	24	50.4	0.90	
Gothic	66	15	39.6	1.99	17.0
Grand Lake	......	......	......	0.06	
Grand Valley	84	24	54.6	1.12	
Greeley	83	27	51.8	0.33	T.
Gunnison	78	16	45.2	1.87	T.
Hahns Peak	65[j]	16[j]	42.6[j]	......	
Hamps	80	21	50.0	0.02	
Hoehne	87	22	51.8	0.55	
Holly	91	25	58.4	0.64	
Holyoke	88	25	53.8	T.	
Idaho Springs	73	25	47.9	0.77	
Colorado—Cont'd.	°	°	°	*Ins.*	*Ins.*
Kossler	......	......	......	0.10	
Kremmling	......	......	......	0.98	T.
Lake City	70	17	49.8	1.20	T.
Lake Moraine	61	13	38.5	1.50	8.0
Lamar	91	27	57.6	0.93	
Laporte	......	......	......	0.15	
Las Animas	90	25	56.1	1.20	
Lay	75	20	47.0	0.34	
Leroy	84	27	53.2	T.	
Limon	82	28	51.9	T.	
Lujane	77	31	53.5	1.42	
Manassa	73	20	56.2	0.30	
Mancos	74	23	50.4	1.25	
Meeker	75	18	48.3	0.60	
Montrose	80	27	53.0	1.02	
Moraine	72	24	44.6	0.89	10.2
Nederland	......	......	......	0.18	T.
Pagoda	76	28	49.2	0.50	
Pagosa Springs	79	20	46.2	1.79	
Paonia	80	33	55.2	1.69	1.0
Platte Canyon	......	......	......	0.96	
Power House	74	27	48.2	1.66	
Rangely	76	17	48.9	1.82	
River Portal	76[e]	29[e]	50.8[e]	2.07	
Rocky Ford	89	21	54.6	0.88	
Saguache	71	24	46.0	1.05	
Salida	79	22	49.1	0.99	2.0
San Luis	74	12	47.0	1.27	
Santa Clara	79	28	48.2	2.38	4.0
Sapinero	68	19	44.2	2.10	1.8
Sheridan Lake	87	19	52.4	0.50	
Silverton	67	19	40.8	1.54	2.0
Stonewall	......	......	......	1.52	
Terminal Dam	......	......	......	1.79	
Trinidad	84	33	58.0	0.58	
Victor	70	29	43.4	0.53	2.7
Vilas	......	......	......	0.82	
Wagon Wheel Gap	72	12	41.2	0.56	T.
Waterdale	82	27	51.2	0.31	
Westcliffe	74	20	45.6	0.64	2.0
Whitepine	69	20	39.3	1.99	12.5
Wray	90	26	54.2	0.03	
Yuma	......	......	......	0.04	
Connecticut.					
Bridgeport	74	26	50.3	5.03	
Canton	71	19	45.8	6.91	
Colchester	70	22	47.0	5.44	
Falls Village	......	......	......	7.81	1.0
Hawleyville	72	23	46.8	6.67	
Lake Konomoc	......	......	......	5.24	
New London	73	30	51.6	4.74	
North Grosvenor Dale	71	19	46.0	5.05	
Norwalk	72	22	47.2	5.38	
Southington	72	22	47.2	5.30	
South Manchester	......	......	......	4.12	
Storrs	......	......	......	4.97	
Voluntown	72[e]	17	47.4[e]	3.97	
Wallingford	......	......	......	3.51	
Waterbury	74	22	48.2	5.89	
West Cornwall	66	24	45.0	9.69	1.0
West Simsbury	......	......	......	6.31	
Delaware.					
Delaware City	......	......	......	1.85	
Dover	78	31	52.8	2.88	
Milford	82	28	53.4	3.14	
Millsboro	82	27	52.0	2.37	
Newark	74	27	50.7	4.23	
Seaford	76	30	51.7	3.06	
District of Columbia.					
West Washington	81	27	52.4	2.35	
Florida.					
Apalachicola	88	47	69.8	0.39	
Arcadia	94	51	74.0	1.45	
Archer	91	39	69.3	5.41	
Avon Park	92	54	74.0	3.83	
Bartow	93	46	73.2	0.39	
Bonifay	89	38	68.2	0.86	
Brooksville	93	47	73.2	0.74	
Clermont	92	53	73.9	0.95	
De Funiak Springs	90	38	68.5	1.57	
Deland	93	47	73.2	......	
Eustis	91	43	71.6	0.89	
Federal Point	91	44	70.4	0.76	
Fenholloway	90	38	69.3	7.80	
Fernandina	89	49	69.8	2.84	
Flamingo	93	62	78.6	2.43	
Fort Meade	91	45	73.0	2.46	
Fort Myers	89	56	74.8	0.55	
Gainesville	89	45	70.4	2.57	
Galt	90	32	68.4	1.15	
Grasmere	89	52	71.5	0.00	
Hypoluxo	90	61	77.0	5.18	
Inverness	89	47	70.0	0.59	
Jasper	91	40	68.2	0.10	
Kissimmee	91	54	73.6	1.45	
Lake City	91	42	68.2	0.39	
Macclenny	......	......	......	1.97	
Madison	91	42	68.4	0.99	

TABLE II.—*Climatological record of cooperative observers*—Continued.

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
	°	°	°	*Ins.*	*Ins.*
***Florida*—Cont'd.**					
Malabar	95	56	75.5	3.39	
Manatee	93	53	74.2	1.55	
Marianna	92	38	67.8	1.07	
Merritts Island	88	57	74.6	1.84	
Miami	93[a]	61	77.2[b]	2.77	
Molino	94	32	67.0	1.00	
Monticello	88	42	68.0	0.16	
Mount Pleasant	91	38	68.0	1.11	
New Smyrna	93	51	71.6	1.47	
Ocala	93	44	71.1	2.55	
Orange City	97	45	72.3	0.12	
Orlando	91	49	72.4	1.91	
Panasoffkee	90	43	70.8	1.14	
Plant City	92	47	72.3	0.21	
Rockwell	91[d]	40[d]	72.4[d]	0.60	
St. Andrew	.....	39	.....	1.19	
St. Augustine	90	46	70.2	2.19	
St. Leo	92	49	72.0	0.30	
Switzerland	89	44	69.6	1.57	
Tallahassee	87	43	67.8	1.20	
Tarpon Springs	91	46	71.6	0.73	
Wausau	92	37	68.1	0.00	
Georgia.					
Adairsville	80[g]	34[i]	60.1[h]	1.55	
Albany	90	38	65.6	0.19	
Allapaha	91	37	66.2	1.45	
Americus	85	38	62.2	0.44	
Athens	79	35	59.6	0.26	
Bainbridge	92	36	67.0	2.03	
Blakely	90	36	65.8	1.51	
Brunswick	93	38	68.4	0.61	
Camak	87	31	62.4	0.40	
Carlton	.....	.....	.....	0.54	
Clayton	78	30	55.2	1.73	
Columbus	88[e]	39[e]	66.2[e]	0.50	
Covington	87[g]	33[g]	59.5[g]	0.27	
Dahlonega	79	30	57.1	1.02	
Diamond	76	31	55.1	1.61	
Dublin	.....	.....	.....	0.25	
Dudley	89	35	64.6	0.58	
Eastman	92	38	66.4	0.06	
Eatonton	87	32	62.4	0.43	
Elberton	83	32	63.8	0.51	
Experiment	82	34	61.8	0.04	
Fitzgerald	91	39	64.6	0.43	
Fleming	93	34	64.2	0.29	
Forsyth	85	35	65.0	0.32	
Fort Gaines	84	39	63.2	1.25	
Gainesville	80	35	56.8	0.36	
Gillsville	81	34	59.9	0.66	
Glenville	87	39	64.4	0.79	
Greenbush	81	33	58.0	1.79	
Greensboro	86	30	60.8	0.13	
Griffin	84	35	62.6	0.33	
Harrison	87	33	62.4	1.35	
Hawkinsville	94	32	62.0	0.60	
Helena	89	38	65.4	0.23	
Lisbon	86	30	61.4	0.50	
Lost Mountain	81	32	61.4	1.70	
Louisville	86	35	63.4	1.15	
Lumpkin	87	34	64.4	1.40	
Marshallville	88	32	63.6	0.85	
Mauzy	92	39	67.2	1.32	
Milledgeville	88	31	62.8	0.55	
Millen	94	32	63.8	1.03	
Montezuma	.....	.....	.....	0.90	
Monticello	85	34	62.8	0.23	
Morgan	87	38	65.3	1.46	
Newnan	85	34	62.2	0.76	
Oakdale	.....	.....	.....	0.72	
Point Peter	82	29	59.6	0.64	
Poulan	88	36	64.8	1.14	
Putnam	88[e]	35[e]	63.7[e]	1.26	
Quitman	87	39	65.1	0.31	
Ramsey	82	33	60.2	1.60	
Rome	84	32	60.4	1.12	
St. George	85	50	68.2	0.48	
St. Marys	92	41	67.5	1.78	
Screven	89	36	65.5	0.10	
Statesboro	85	37	63.2	1.59	
Talbotton	87	34	60.8	0.89	
Tallapoosa	84	36	61.8	0.71	
Toccoa	79	29	57.2	1.03	
Valdosta	93	48	71.4	0.30	
Valona	90	37	64.8	0.21	
Washington	85	32	61.6	0.10	
Way Cross	92	36	67.8	0.25	
Waynesboro	85	30	62.0	1.10	
West Point	84	35	60.8	1.42	
Woodbury	86	30	60.0	0.69	
Idaho.					
Albion	82	26	51.6	T.	
American Falls	81	28	51.6	0.89	
Blackfoot	77	26	50.8	0.47	
Bonners Ferry	73	30	50.6	0.31	
Buhl	80	34	56.6	0.84	
Burke	75	28	48.2	0.77	T.
Caldwell	81	28	55.8	0.42	
***Idaho*—Cont'd.**					
Cambridge	87	28	55.4	1.22	
Chesterfield	77	17	47.6	1.47	
Cœur d 'Alene	.....	.....	.....	0.72	
Dent	84	33	55.2	0.84	
Driggs	70	20	45.0	0.84	
Ellerslie	83	33	57.0	1.32	
Emmett	82	28	56.7	0.67	
Forney	73	16	44.0	0.61	0.7
Garnett	85	33	59.1	1.02	
Grace	85	27	53.4	1.69	
Hot Springs	80	33	56.6	0.97	
Idaho Falls	80	26	51.4	0.68	
Kellogg	82	28	51.4	0.56	
Lake	70	24	47.2	1.50	
Lakeview	66[l]	35	48.8[e]	0.90	
Landore	74	25	50.0	2.79	
Lardo	77	21	47.2	1.60	
Lost River	74	24	48.6	0.28	
Meadows	81	22	50.2	1.42	
Milner	76	30	53.6	0.94	
Moscow	80	32	55.7	0.78	
Mountain Home	86	22	55.2	1.02	
Murray	78	25	47.8	0.77	
Murtaugh	80[e]	29[d]	52.1[e]	0.65	
Nevens Ranch	.....	.....	.....	1.40	
Oakley	82	28	55.6	1.25	
Orofino	92	31	56.5	1.22	
Paris	85[m]	27[m]	50.8[m]	1.24	
Payette	88	30	56.0	0.91	
Pollock	81	31	55.4	0.94	
Poplar	.....	.....	.....	0.20	
Porthill	69	30	48.2	0.81	
Roosevelt[g]	67	21	45.3	.....	
Rupert	81	30	54.1	0.83	
St. Maries	85	30	53.3	0.71	
Salem	.....	.....	.....	0.92	
Salmon	72	22	46.6	0.80	
Standrod	.....	.....	.....	1.61	0.5
Sugar City	75	24	48.2	1.31	
Twin Falls	81	31	53.4	1.19	
Vernon	78	27	50.4	0.75	
West Lake	.....	.....	.....	0.87	
Weston	80[f]	30[f]	51.2[f]	1.36	
Illinois.					
Albion	82	28	55.2	2.21	
Aledo	82	20	51.1	0.62	
Alexander	84	23	54.0	1.55	
Antioch	82	24	49.2	1.05	
Astoria	83	19	51.2	0.51	T.
Aurora	79	25	48.3	1.43	T.
Benton	.....	.....	.....	2.30	
Bloomington	87	26	53.0	1.33	
Bushnell	86	22	53.8	0.45	
Cambridge	84	21	51.2	0.58	
Carlinville	83	23	54.6	1.52	
Carlyle	.....	.....	.....	2.86	
Carrollton	86	24	55.2	3.75	
Charleston	83	27	53.3	2.19	
Chester	88	31	59.5	2.96	
Cisne	84	27	57.2	2.32	
Coatsburg	84	23	53.4	1.25	
Cobden	87	29	58.2	4.22	
Colchester	85	22	52.9	0.57	
Decatur	85	25	53.0	1.01	
Dixon	81	20	47.4	1.71	
Dwight	87	27	51.2	0.45	
Equality	86	30	57.1	3.88	
Flora	81	25	54.3	1.89	
Friendgrove	81	29	54.7	2.76	
Galva	83	21	50.2	0.65	
Grafton	.....	.....	.....	2.32	
Greenville	82	27	55.4	3.28	
Griggsville	84	25	54.8	1.70	
Havana	86	22	54.8	0.59	
Henry	82	22	51.6	0.80	
Hillsboro	82	26	55.4	3.90	
Hoopeston	81	28	51.6	0.94	
Joliet	80	29	49.9	0.66	T.
Kishwaukee	82	23	49.4	0.74	
Knoxville	.....	.....	.....	0.11	
La Grange	81[e]	29[e]	49.8[e]	1.05	
La Harpe	87	20	52.4	0.30	
Lanark	83	17	47.5	1.42	
Lincoln	84	26	53.7	1.28	
Loami	.....	.....	.....	1.48	
McLeansboro	81	29	55.8	1.96	
Martinsville	85	25	53.5	2.65	
Martinton	89	27	51.1	0.65	
Mascoutah	84	27	55.0	2.82	
Minonk	82	26	51.7	0.44	
Monmouth	83	21	52.4	0.74	
Morrison	81	21	50.4	1.44	
Morrisonville	83	23	53.4	1.62	
Mount Carmel	.....	.....	.....	2.02	
Mount Vernon	84	28	56.1	3.49	
New Burnside	86	25	56.2	3.10	
Olney	82	29	55.1	2.43	
Ottawa	83	28	51.0	1.00	
***Illinois*—Cont'd.**					
Palestine	82	27	54.4	2.70	
Pana	82	25	53.8	1.95	
Paris	83	28	52.3	2.79	
Philo	85	23	51.2	2.18	
Pontiac	84	29	53.0	0.61	
Rantoul	.....	.....	.....	1.39	T.
Raum	89	28	57.8	2.68	
Riley	81	26	48.8	0.50	
Robinson	80	28	55.0	3.17	
Rockford	79	25	48.2	0.82	
Rushville	84	22	55.0	0.84	
St. Charles	82	23	49.1	1.53	
St. John	85[c]	27[c]	55.4[c]	1.96	
Streator	87	22	50.6	0.51	
Sullivan	83	26	54.2	1.90	
Sycamore	82	25	48.0	1.26	
Tilden	84	27	56.6	3.01	
Tiskilwa	83	21	50.6	0.66	
Tuscola	86	24	53.8	1.82	
Urbana	89	28	51.4	1.51	
Vernon	81	26	54.8	4.08	
Walnut	83	22	51.6	0.51	
Warsaw	.....	.....	.....	0.60	
Windsor	85	22	53.3	1.30	
Winnebago	82	22	48.4	0.71	
Yorkville	83	25	48.4	1.07	
Zion	79	20	48.6	1.06	
Indiana.					
Anderson	82	26	51.0	1.89	
Auburn	79	22	44.4	2.61	
Bloomington	82	29	57.4	4.80	
Bluffton	83	24	49.0	2.17	
Butlerville	84	24	53.0	3.87	
Cambridge City	84	23	48.4	2.89	
Columbus	84	24	52.1	3.42	
Connersville	82	23	49.6	3.42	
Delphi	86	23	48.8	1.31	
Elkhart	82	29	48.6	2.53	
Eminence	83	25	52.4	4.38	
Farmersburg	81[k]	32[m]	56.8[l]	.....	
Farmland	80	25	49.6	2.73	
Fort Wayne	83	25	50.0	1.77	
Franklin	86	23	52.2	4.07	
Greenfield	84	26	52.2	2.57	
Greensburg	84[d]	30	53.2	3.44	T.
Holland	87	28	56.4	3.89	
Huntington	82	25	49.7	1.85	
Jeffersonville	87	28	55.1	3.08	
Judyville	83	23	51.0	1.65	
Knox	77	23	49.4	1.87	T.
Kokomo	85	25	49.4	2.42	T.
La Fayette	85	27	50.0	1.74	
Laporte	82	25	48.2	1.90	T.
Lima	80	25	46.3	2.80	
Logansport	89	26	50.2	1.70	
Madison	85	27	54.3	3.48	
Marengo	85	26	54.2	3.34	T
Marion	84	25	49.8	2.35	T.
Markle	82	23	49.2	1.75	
Mauzy	85	22	51.1	3.52	T.
Moores Hill	84	26	52.4	3.01	
Mount Vernon	88	29	56.4	3.38	
Northfield	83	19	48.8	2.55	
Paoli	85	23	54.8	2.66	
Plymouth	79	24	47.9	1.32	
Princeton	82	29	51.8	2.35	
Rensselaer[e]	83	25	51.2	.....	
Richmond	83	23	49.8	3.29	
Rochester	72	27	49.3	1.60	
Rockville	81	27	52.2	3.37	
Rome	89	28	57.2	2.99	
Salamonia	83	23	49.4	1.88	
Salem	85	23	52.6	3.38	T.
Shelbyville	86	24	51.8	4.11	T.
South Bend	83	27	48.4	2.43	
Terre Haute	83	31	55.4	2.32	
Veedersburg	84	24	53.2	1.50	
Vevay	83	28	54.5	4.50	
Vincennes	86	29	54.4	2.90	
Washington	83	27	53.3	2.45	
Worthington	83	26	54.2	3.87	
Zelma	74[f]	23[f]	50.5[f]	.....	
Indian Territory.					
Ada	90	37	63.2	3.63	
Ardmore	95	39	64.0	5.04	
Calvin	.....	.....	.....	4.13	
Chickasha	93	36	63.4	5.17	
Durant	95	39	63.5	10.96	
Fairland	91[f]	28[f]	62.6[f]	.....	
Fort Gibson	.....	.....	.....	3.09	
Healdton	93	34	61.6	3.05	
Holdenville	87	35	61.2	3.50	
Idabel	92	38	63.1	4.76	
Marlow	93	39	61.9	6.75	
Muskogee	93	32	62.0	2.70	
Okmulgee	89	30	61.8	2.41	
Pauls Valley	90	33	61.8	4.45	
Ravia	93	41	64.2	3.88	

TABLE II.—*Climatological record of cooperative observers*—Continued.

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Indian Territory—Cont'd.	°	°	°	*Ins.*	*Ins.*
South McAlester	92	35	64.4	2.30	
Tulsa	90	34	60.9	5.27	
Vinita	93	27	61.4	......	
Wagoner	84	29	61.2	2.32	
Webbers Falls	88	27	61.0	1.97	
Iowa.					
Afton	76	20	51.4	1.99	
Albia	81	19	50.1	1.61	
Algona	76	19	48.3	0.92	
Allerton	81	18	52.6	1.26	
Alta	80	22	48.4	1.19	
Alton	79	16	50.0	0.93	
Amana	77	19	49.8	1.31	
Ames	81	15	49.8	3.04	
Atlantic	79	11	49.2	1.77	
Audubon	78	10	49.0	0.89	
Baxter	81	15	50.6	3.52	
Bedford	78	14	52.3	2.72	
Belle Plaine	80	17	49.8	3 18	
Bloomfield	84	20	53.1	1.22	
Bonaparte	82	18	52.4	0.81	
Boone	81	25	50.0	3.71	
Britt	78	16	47.6	0.90	
Buckingham	......	......	......	2.26	
Burlington	84	22	52.6	0.64	
Carroll	79	16	48.1	2.32	
Cedar Rapids	80	21	48.8	2.08	
Chariton	81	18	52.3	1.27	
Clarinda	83	16	51.6	2.48	
Clear Lake	72	25	49.2	1.27	
Clinton	79	21	49.4	1.59	
Columbus Junction	81	22	51.8	1.16	
Corning	76	14	50.9	2.33	
Corydon	81	19	53.6	1.18	
Creston	76	17	49.6	2.47	
Cumberland	......	......	......	2.81	
Decorah	75	18	47.6	0.96	
Delaware	74	19	47.4	1.67	
Denison	82	14	50.6	0.82	
De Soto	79	15	51.5	1.89	
Dows	82	15	48.6	0.93	
Earlham	82	16	50.4	1.62	
Elkader	84	15	48.2	0.93	
Elliott	76	15	50.6	1.34	
Elma	75	14	46.6	0.89	T.
Estherville	77	18	47.2	2.40	
Fayette	79	13	47.2	1.68	
Forest City	82	22	47.6	1.00	
Fort Dodge	82	19	48.8	2.16	
Fort Madison	......	......	......	0.32	
Gilman	......	......	......	2.89	
Grand Meadow	75	21	47.8	1.15	
Greene	77	18	49.4	0.76	
Greenfield	77	21	51.5	2.13	
Grinnell	81	18	52.0	2.73	
Grundy Center	81	19	49.6	1.46	
Guthrie Center	80	15	51.4	1.39	
Hampton	85	21	50.0	0.83	
Hancock	77	18	52.0	0.77	
Harlan	81	13	50.2	2.64	
Humbolt	78	16	49.5	1.12	
Independence	79	16	49.1	1.92	
Indianola	77	22	52.0	1.10	
Inwood	81	15	49.3	0.64	
Iowa City	84	19	50.0	0.86	
Iowa Falls	78	16	47.6	0.65	
Jefferson	82	17	51.8	1.44	
Keosauqua	85	17	50.4	1.03	
Knoxville	80	20	52.6	1.73	
Lacona	......	......	......	3.10	
Larrabee	80	16	48.8	1.27	
Le Claire	......	......	......	0.69	
Le Mars	76	20	50.0	0.59	
Lenox	77	19	52.6	2.11	
Leon	79	21	53.0	1.79	
Little Sioux	83	20	53.0	0.81	
Logan	80	10	51.5	1.18	
Maple Valley	......	......	......	1.90	
Marshalltown	82	18	48.4	2.19	
Mason City	77	18	48.4	0.85	
Massena	85[e]	10[e]	53.2[e]	1.15	
Mount Ayr	82	25	53.5	2.83	
Mount Pleasant	81	21	51.8	1.19	
Murray	80	22	52.5	1.70	
Muscatine	......	......	......	1.09	
New Hampton	73	18	47.0	0.67	
Newton	76	24	52.2	2.65	
Northwood	76	19	47.6	1.78	
Odebolt	83	19	51.4	1.91	
Olin	82	18	48.8	1.02	
Onawa	83	24	54.1	0.99	
Osage	80	16	49.0	1.00	
Oskaloosa	78	15	51.8	1.07	
Ottumwa	84	21	53.0	1.14	
Pacific Junction	79	16	51.2	1.10	
Pella	80	21	52.9	1.97	
Perry	77	18	50.5	3.31	
Plover	76	12	46.2	3.30	

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Iowa—Cont'd.	°	°	°	*Ins.*	*Ins.*
Pocahontas	76	20	48.0	2.96	
Ridgeway	81	20	49.6	1.12	
Rock Rapid	80	20	46.3	1.00	
Rockwell	78	24	51.8	2.10	
Sac City	......	......	......	2.75	
St. Charles	81	23	53.6	1.29	
Sheldon	83	19	49.9	1.87	
Sibley	80	20	46.3	0.96	
Sigourney	81	19	51.7	1.08	
Sioux Center	77	20	48.0	0.82	
Stockport	80	17	51.8	1.22	
Storm Lake	79	24	50.6	1.90	
Stuart	......	......	......	1.26	
Thurman	78	17	52.8	1.09	
Tipton	80	25	51.6	0.30	
Toledo	79	16	49.8	2.20	
Wapello	78	23	51.5	1.26	
Washington	80	20	51.0	0.95	
Waterloo	82	20	50.6	1.54	
Waukee	77	20	51.4	1.94	
Waverly	78	18	48.7	0.67	
Webster City	78	14	49.6	1.26	
West Bend	76	18	47.8	1.55	
Whitten	76	17	49.8	1.48	T.
Wilton Junction	78	20	50.4	0.87	
Winterset	75	23	52.0	1.62	
Zearing	80	15	49.4	1.63	
Kansas.					
Abilene	......	......	......	2.64	
Anthony	92[d]	35[d]	62.8[d]	4.53	
Ashland	92	31	57.8	2.63	
Atchison	84	26	57.0	2.08	
Baker	87	27	56.7	3.90	
Burlington	90	25	58.7	3.99	
Chapman	89	26	56.8	3.41	
Cimarron	91	30	58.4	1.96	
Clay Center	90	25	57.0	2.33	
Colby	84	31	55.6	1.17	
Coldwater	89	36	58.8	2.89	
Columbus	88	29	58.6	5.27	
Coolidge	93	23	55.8	0.41	
Cottonwood Falls	89	27	57.1	5.69	
Cunningham	92	34[e]	60.2[e]	5.62	
Dresden	89[e]	30	56.1[e]	1.12	
Eldorado	88	31	57.8	6.31	
Ellinwood	90	34	57.8	2.18	
Ellsworth	88	29	56.4	1.48	
Emporia	90	28	57.4	7.00	
Enterprise	89	27	58.1	2.47	
Eskridge	86	31	56.5	2.31	
Eureka	......	......	......	5.47	
Fall River	90	27	58.4	4.84	
Farnsworth	89	29	56.8	0.58	
Fort Scott	88[c]	24	57.7	4.31	
Frankfort	89	20	56.0	2.10	
Fredonia	90[c]	29[c]	58.2[d]	5.34	
Garden City	88	28	57.4	1.45	
Garnett	87	24	57.6	4.55	
Goodland	90	29	55.8	0.91	T.
Gove*[1]	79	31	55.4	1.57	
Greensburg	86	33	57.8	1.90	
Grenola	87	31	57.8	5.01	
Hanover	89	25	56.2	3.51	
Harrison	84	26	54.2	1.98	
Hays	88	31	56.2	1.40	
Hill City	91	30	56.6	0.47	
Horton	83	27	56.3	3.03	
Howard	89	30	57.7	3.64	
Hoxie	88	30	55.4	0.97	
Hugoton	......	......	......	1.58	
Hutchinson	91	32	58.0	3.98	
Independence	89	32	60.0	4.59	
Jetmore	92	31	58.2	2.51	
Jewell	86	29	54.2	2.41	
La Crosse	88	31	57.5	1.56	
Lakin	......	29	......	0.66	
Larned	90	31	57.0	3.31	
Lebanon	81[c]	32	55.8[b]	0.97	
Lebo	86	28	57.1	4.79	
Liberal	90	32	58.2	1.92	
Macksville	90	33	57.2	2.66	
McPherson	91[b]	31	58.2[d]	5.16	
Madison	90	24	57.6	3.83	
Manhattan	92	24	55.4	2.71	
Manhattan Agr. College	89	23	55.8	2.63	
Minneapolis	89	30	55.7	1.52	
Moran	90	29	59.2	5.02	
Mount Hope	......	......	......	3.38	
Newton	89	31	57.9	5.24	
Norton	88	25	54.8	0.12	
Norwich	90	36	60.2	4.88	
Oberlin	......	......	......	0.45	
Olathe	82	29	57.0	3.10	
Osage City	88[d]	24[d]	56.9[d]	2.86	
Oswego	89	29	59.6	3.90	
Ottawa	86	22	55.6	5.01	
Paola	85	25	56.6	4.31	
Plainville	79[e]	32	55.4[e]	0.11	

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Kansas—Cont'd.	°	°	°	*Ins.*	*Ins.*
Pleasanton	85	27	57.5	4.67	
Pratt	85	34	58.0	4.47	
Republic	84	29	55.2	2.59	
Rome	90	31	58.8	5.98	
Russell	86	32	57.4	3.04	
Salina	86	29	57.6	3.08	
Scott	89	27	56.8	1.48	
Sedan	88	30	58.6	4.18	
Toronto	93	28	58.9	7.80	
Ulysses	90[e]	34[e]	58.2[e]	1.62	
Valley Falls	85	23	55.8	2.41	
Wakeeney	90	30	57.6	0.64	
Wakeeney (near)	......	......	......	1.05	
Wallace	91	27	56.0	0.73	
Walnut	87	29	59.0	5.04	
Winfield	85	32	58.4	4.90	
Yates Center	91	27	59.6	6.18	
Kentucky.					
Alpha	80	30	57.2	2.50	
Anchorage	87[f]	24[f]	55.4[f]	3.73	
Bardstown	88	24	56.1	2.84	
Beattyville	86	31	53.6	2.47	
Beaver Dam	82	25	55.0	2.76	
Berea	84	23	55.2	1.90	
Blandville	89	31	58.1	3.98	
Bowling Green	90	28	58.7	3.46	
Burnside	86	27	55.8	3.38	
Cadiz	87	28	57.1	3.19	
Calhoun	87	28	57.6	3.72	
Catlettsburg	89	26	56.3	2.30	
Earlington	86	29	55.4	2.98	
Edmonton	86	24	55.8	2.49	
Eubank	84	24	53.0	3.13	
Falmouth	......	......	......	2.80	
Frankfort	87	26	54.2	3.52	
Franklin	89	28	58.1	2.09	
Greensburg	93	22	52.8	3.33	
Hopkinsville	88	28	57.0	2.95	
Irvington	86	28	56.0	3.13	
Leitchfield	86	27	55.4	3.40	
Loretto	90	22	56.6	3.30	
Lynnville	90	29	57.9	2.28	
Marion	85	31	59.0	4.19	
Maysville	88	26	52.9	2.71	
Mount Sterling	84	27	53.0	2.85	
Owensboro	85	30	56.9	4.15	
Owenton	82[e]	30	54.0[e]	3.45	
Paducah	90	35	59.9	2.82	
Richmond	84	27	55.2	1.12	
St. John	86	25	53.5	3.37	
Scott	85	26	53.2	3.28	
Shelby City	87	20	54.2	1.84	
Shelbyville	84	24	52.4	3.15	T.
Taylorsville	86	25	53.7	4.66	
West Liberty[h]	85	25	55.0	......	
Williamstown	83	28	53.3	3.65	
Louisiana.					
Abbeville	90	41	69.8	7.97	
Alexandria	94	38	68.6	5.15	
Amite	90	37	67.0	3.66	
Baton Rouge	95	33	67.4	7.60	
Burnside	89	38	68.2	2.86	
Cameron	88	44	71.2	7.13	
Cheneyville	91	36	66.4	2.70	
Clinton	90	38	67.8	1.53	
Collinston	90	37	65.0	1.55	
Covington	93	39	68.6	1.73	
Donaldsonville	92	42	70.2	8.46	
Ferriday	93	36	68.8	3.37	
Franklin	94	43	70.6	7.47	
Grand Cane	92	36	66.0	6.05	
Grand Coteau	93	40	70.8	6.08	
Houma	89	40	68.2	3.12	
Jennings	89	40	69.0	14.26	
La Fayette	89	39	68.0	9.11	
Lake Charles	94	40	69.5	8.55	
Lakeside	90	47	69.8	9.30	
Lawrence	90	50	72.0	1.63	
Libertyhill	94	35	66.2	3.78	
Melville	96	35	69.2	1.95	
Minden	97	32	64.8	3.42	
Monroe	98	38	67.0	3.17	
Newellton	92	34	65.4	2.45	
New Iberia	87	42	69.6	5.80	
Opelousas	94	38	69.6	3.45	
Plain Dealing	94	33	66.8	2.22	
Rayne	94	40	69.4	7.76	
Reserve	94	43	70.8	2.55	
Robeline	93	29	65.6	1.68	
Ruston	92	36	66.9	3.00	
St. Francisville	91	41	68.2	0.25	
Schriever	95	39	70.4	3.42	
Southern University	......	......	......	2.26	
Sugar Experiment Station	89	46	70.5	0.57	
Sugartown	89	39	68.3	2.00	
Tallulah	95	34	66.1	2.41	

TABLE II.—*Climatological record of cooperative observers*—Continued.

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
	°	°	°	Ins.	Ins.
Maine.					
Bar Harbor	66	21	44.8	4.90	T.
Cornish	71	19	43.6	4.06	0.2
Danforth	......	......	......	3.88	
Debsconeag	68	19	42.8	4.50	3.0
Fairfield	65	17	43.1	2.34	......
Farmington	72	15	42.6	6.15	......
Gardiner	70	18	45.6	4.15	T.
Houlton	67	16	43.5	3.10	T.
Lewiston	72	21	46.0	3.56	
Madison	69	17	42.4	6.31	......
Mayfield	60	19	39.8	6.11	T.
Millinocket	71	19	43.8	4.14	......
North Bridgton	72	19	45.9	4.49	T.
Orono	67	15	44.4	2.71	
Rumford Falls	66	18	42.8	5.17	0.5
The Forks	......	......	......	4.63	2.0
Van Buren	70	10	39.0	2.87	1.7
Winslow	69	14	43.5	3.24	
Maryland.					
Annapolis	77	36	52.8	3.43	
Bachmans Valley	......	......	......	1.85	
Cambridge	82	30	54.8	3.71	
Cheltenham	82	29	51.4	2.79	
Chestertown	73	31	52.0	3.90	
Chewsville	77	22	48.8	1.82	T.
Clear Spring	75	27	49.6	1.25	
Coleman	75	31	53.4	3.15	
College Park (Md.Ex.Sta.)	81	24	49.6	2.02	
Cumberland	......	......	......	1.29	
Darlington	74	26	49.8	2.62	
Deer Park	77	15	46.2	2.98	
Denton	81	25	51.8	3.49	
Easton	77	30	52.7	3.73	
Fallston	76	29	50.2	2.67	
Frederick	78	27	51.0	1.91	
Frostburg	......	......	......	1.67	
Grantsville	75	23	45.2	2.18	
Great Falls	83	24	49.2	2.00	
Greenspring Furnace	80	21	49.6	1.03	
Harney	......	......	......	1.69	
Jewell	80	30	53.0	2.99	
Keedysville	82	23	51.4	1.58	
Lake Montebello	......	......	......	1.78	
Laurel	80	25	50.4	2.12	
Monrovia	78	28	50.3	1.25	
Mount St. Marys College	75	29	50.8	1.64	
Oakland	75	17	44.7	2.59	
Ocean City	......	......	54.8[e]	2.23	
Pocomoke City	78	30	53.5	2.76	
Portobello	81	34	54.2	2.50	
Princess Anne	79	26	52.0	2.70	
Salisbury	80	25[e]	52.4[e]	3.51	
Solomons	77	38	54.4	2.65	
Sudlersville	77	28	52.0	2.68	
Takoma Park	78	29	50.2	2.29	
Taneytown	78	23	48.8	2.27	
Towson	......	......	......	1.63	
Van Bibber	......	......	......	3.18	
Western Port	83	25	49.7	1.50	
Woodstock	76	26	45.6	1.86	
Massachusetts.					
Amherst	73	20	46.0	5.00	
Bedford	68	24	46.0	4.20	
Bluehill (summit)	70	27	46.3	3.40	
Chestnut Hill	72	21	49.1	3.65	
Concord	70	17	45.2	4.73	
Fall River	67	29	49.0	2.35	
Fitchburg	71	20	46.8	4.87	T.
Framingham	70	16	45.4	3.83	
Groton	69	16	44.6	5.17	
Hyannis	64	28	48.2	1.92	
Jefferson	......	......	......	6.51	2.0
Lawrence	72	20	46.8	4.10	
Leominster	......	......	......	4.87	T.
Lowell	70	21	47.8	4.49	
Middleboro	70	16	46.9	2.90	
Monson	69	22	45.4	6.67	
Plymouth	67	27	47.8	2.56	
Princeton	......	......	......	5.48	
Provincetown	65	31	49.0	2.31	
Salem	......	......	......	2.29	
Somerset	75	23	49.3	2.80	
Taunton	69	15	45.5	3.51	
Westboro	78	19	48.0	4.43	
Weston	......	......	......	3.52	
Williamstown	70	25	44.2	6.50	0.6
Winchendon	......	......	......	4.77	
Worcester	70	26	47.6	4.79	T.
Michigan.					
Adrian	80	24	47.2	2.10	
Agricultural College	78	23	46.0	2.22	0.3
Alma	77	17	44.8	0.87	
Ann Arbor	78	20	45.6	1.77	
Arbela	78	20	45.0	2.72	
Ball Mountain	76	24	45.0	2.12	1.7
Battle Creek	78	24	46.5	2.01	
Bay City	78	18	47.2	0.60	
Berlin	77	20	44.8	1.97	2.5

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
	°	°	°	Ins.	Ins.
***Michigan*—Cont'd.**					
Big Rapids	77	15	44.2	0.68	
Blaney	57	16	36.8	1.87	
Bloomingdale	80	24	49.0	1.40	T.
Calumet	68	23	42.4	1.91	T.
Cassopolis	80	27	47.8	1.35	
Charlevoix	72	26	46.6	1.44	
Charlotte	......	21	......	1.35	
Chatham	72	14	40.9	2.48	
Cheboygan	72	20	44.2	2.17	
Clinton	69	19	45.0	1.87	
Coldwater	80	24	49.9	2.15	
Concord	75	22	45.2	2.56	T.
Deer Park	67	18	42.8	1.61	
Detour	65	25	42.6	2.52	T.
Dundee	79	20	46.4	2.24	0.8
Eagle Harbor	68	28	43.5	1.33	T.
East Tawas	71[c]	19[c]	43.5[c]	0.56	
Eloise	78	22	47.4	1.91	T.
Ewen	69	15	41.5	1.72	......
Flint	80	20	44.2	1.65	
Frankfort	68	26	47.6	0.90	
Grand Marais	70	30	42.4	1.81	
Grape	79	25	47.4	2.71	
Grass Lake	80	23	46.4	1.96	
Harbert	80	25	51.8	2.30	T.
Harbor Beach	76	24	44.9	0.96	
Harrison	72	15	44.6	0.65	
Harrisville	71	20	43.8	0.86	
Hart	......	20	......	2.25	
Hayes	78	15	46.1	0.34	
Highland	......	......	......	2.41	2.0
Hillsdale	77	25	46.3	2.22	
Holland	76	23	48.6	1.99	T.
Howell	77	22	45.3	2.38	T.
Humboldt	67	10	38.2	2.25	T.
Iron Mountain	74	17	43.8	0.87	
Iron River	68	14	41.3	1.50	T.
Ishpeming	......	......	......	1.80	
Isle Royal	55	28	41.9	1.50	T.
Ivan	76	14	42.7	1.88	T.
Jackson	82	24	48.0	2.00	
Jeddo	74	23	45.6	1.53	
Kalamazoo	78	25	48.2	1.84	
Lake City	70	......	......	1.68	T.
Lansing	79	24	46.6	2.00	
Lapeer	82	21	46.4	1.62	T.
Ludington	70[d]	20[d]	47.6[d]	0.92	
Mackinaw	73	23	45.6	......	
Mackinac Island	67	23	42.1	......	T.
Mancelona	77	17	43.9	2.50	
Manistee	72[e]	20[f]	46.8[f]	......	......
Maple Ridge	72	14	41.6	2.10	
Menominee	75	26	46.3	0.40	
Montague	71	20	45.4	0.91	
Morenci	81	24	47.3	2.40	
Mount Clemens	......	20	......	1.55	T.
Mount Pleasant	76	13	43.4	0.20	
Muskegon	72	23	46.4	0.65	
Old Mission	73	26	45.2	1.37	
Olivet	75	23	45.9	2.11	T.
Owosso	78	20	46.4	1.80	
Petoskey	72	22	45.1	1.85	T.
Port Austin	84	25	49.2	0.66	
Powers	68	15	41.3	......	
Reed City	75	15	43.2	1.25	
Roscommon	75[d]	10[d]	43.0[d]	0.79	T.
Saginaw (W. S.)	79	20	46.6	1.41	
St. Ignace	70	19	43.4	1.50	
St. James	70	10	41.2	......	
St. Joseph	76	30	50.3	1.74	
Saranac	78	20	45.6	1.44	
South Haven	70	22	45.6	1.76	
Thomaston	67	15	42.6	0.90	
Thornville	74	18	45.7	3.22	5.0
Traverse City	73[d]	25[d]	47.8[d]	0.67	
Vassar	68	18	44.9	2.60	
Wasepi	78	25	47.1	2.71	
Webberville	79	20	46.0	1.61	0.5
West Branch	75	28	45.0	0.45	T.
Wetmore	70	15	41.2	1.00	
Whitefish Point	71	24	43.1	2.58	T.
Woodlawn	74	11	41.0	1.64	T.
Ypsilanti	79	24	46.8	2.57	
Minnesota.					
Albert Lea	78	20	49.6	1.50	T.
Alexandria	78	21	45.4	1.23	
Angus	72	10	42.2	0.83	
Bagley	71	15	42.4	0.79	
Beardsley	......	......	......	0.87	
Beaulieu	72	14	43.9	0.39	
Bird Island	78	20	47.4	0.98	
Blackduck	73	15	42.7	2.83	
Caledonia	73	19	46.6	0.75	
Cass Lake	......	......	......	1.29	
Collegeville	75	23	47.0	0.96	
Crookston	72	17	41.8	0.83	
Detroit	77	10	42.0	0.85	
Fairmount	75	26	47.4	2.00	

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
	°	°	°	Ins.	Ins.
***Minnesota*—Cont'd.**					
Faribault	76	19	46.6	0.84	
Farmington	73	21	46.8	1.27	T.
Fergus Falls	79	20	46.6	1.16	
Floodwood	74	17	42.5	1.44	
Fort Ripley	......	......	......	1.06	
Glencoe	77	21	47.3	1.34	
Grand Meadow	78	18	46.6	1.51	
Hallock	68	9	42.2	0.56	
Halstad	75	13	42.2	1.52	
Hinckley	78	16	44.5	0.80	T.
Howland	61	26	44.3	0.89	
Lake Crystal	74	21	47.6	2.48	
Leech Lake	72	19	42.6	1.14	
Litchfield	75	20	46.6	1.86	
Little Falls	77	20	45.5	0.91	
Long Prairie	77	17	44.8	1.10	
Luverne	74	18	46.8	1.28	
Lynd	83	16	46.8	1.36	
McIntosh	74	13	42.9	0.52	
Milacca	73[f]	18[f]	43.8[f]	......	
Milan	79	14	45.4	1.89	
Minneapolis *[1]	75	21	45.7	1.07	
Montevideo	84	13	47.6	1.32	
Mora	76	16	44.0	1.36	
Morris	77	16	45.6	1.87	
Mount Iron	74	14	40.0	1.20	2.0
New London	83	29	47.5	0.89	
New Richland	78	24	48.0	2.74	
New Ulm	80	22	45.4	1.39	
Osakis	76	21	45.0	1.61	
Park Rapids	74[f]	16[f]	41.5[f]	......	
Pine River	71	18	42.5	1.50	T.
Pipestone	74	21	47.5	0.7[illegible]	
Pokegama Falls	76	18	42.4	1.[illegible]	
Redwood Falls	83	20	48.6	1.14	
Reeds	......	......	......	1.52	
St. Charles	77	18	47.7	1.46	
St. Cloud	81	22	47.7	1.67	T.
St. Peter	73	18	46.6	1.36	
Sandy Lake Dam	74	21	44.7	1.10	T.
Shakopee	75	18	47.2	1.99	
Stephens Mines	73	12	39.6	0.84	......
Taylors Falls	88	9	43.7	......	
Tonka Bay	......	......	......	1.45	
Two Harbors	72	21	43.7	0.66	
Wabasha	83	18	49.8	1.72	
Windom	79	18	48.4	1.66	
Winnebago	80	22	48.4	0.99	
Winnebigoshish	71	25	44.1	1.12	
Winona	78	21	47.4	0.80	
Worthington	75	21	46.0	1.83	
Zumbrota	77	17	45.8	1.50	T.
Mississippi.					
Aberdeen	91	32	63.2	1.45	
Agricultural College	94	35	63.5	1.17	
Anguilla	91	34	63.6	3.38	
Austin	90	31	62.4	2.53	
Batesville	94	32	64.6	2.55	
Bay St. Louis	87	46	69.4	0.59	
Bellefontaine	......	31	......	1.90	
Biloxi	92	46	71.6	1.44	
Booneville	85[e]	33[e]	60.2[e]	3.64	
Brookhaven	91	37	66.2	1.82	
Canton	92	34	65.0	1.81	
Clarksdale	88	30	61.5	1.85	
Columbia	......	......	......	0.60	
Columbus	91	32	62.8	1.62	
Corinth	86	34	59.1	2.67	
Crystal Springs	91	37	65.3	3.37	
Duck Hill	93	29	61.8	2.20	
Edwards	91	36	66.8	2.90	
Enterprise	......	......	......	0.97	
Fayette	89	35	64.3	3.70	
Fayette (near)	......	......	......	3.78	
Greenville	89	36	63.6	3.24	
Greenwood	91	33	62.4	1.86	
Hattiesburg	92	35	67.0	2.20	
Hazlehurst	92	37	65.8	2.08	
Hernando	91	34	62.6	3.10	
Holly Springs	92	34	61.1	2.65	
Jackson	90	55	63.8	2.48	
Kosciusko	92	32	63.4	2.53	
Lake	91	31	63.1	1.26	
Lake Como	91	31	65.6	1.55	
Laurel	91	34	66.5	1.64	
Leakesville	91	36	67.8	0.47	
Louisville	92	34	64.0	2.31	
McNeill	90	38	69.1	1.32	
Macon	92	33	62.6	1.21	
Magnolia	93	37	67.8	2.53	
Monticello	92	33	66.6	2.38	
Natchez	92	40	67.0	4.59	
Okolona	90	34	62.0	1.21	
Pearlington	89	38	68.8	1.88	
Pecan	88	39	68.3	1.88	
Pittsboro	90	32	62.6	2.97	
Pontotoc	89	33	62.6	1.60	
Porterville	......	31	......	2.35	

TABLE II.—*Climatological record of cooperative observers*—Continued.

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
	°	°	°	*Ins.*	*Ins.*
***Mississippi*—Cont'd.**					
Port Gibson	92	34	64.4	2.84	
Quitman	94	29	65.4	0.74	
Ripley	91	30	62.2	3.70	
Rosedale	89	32[k]	61.4[f]	1.97	
Shoccoe	90[h]	35[h]	65.5[h]	1.66	
Shubuta				1.30	
Suffolk	91	37	67.8	4.04	
Tchula				3.40	
Tupelo	91	33	61.6	1.56	
University	93	34	64.4	1.63	
Utica	91	36	65.6	2.77	
Water Valley	94	33	63.5	5.08	
Waynesboro	90	30	64.3	0.45	
Woodville	89	35	67.0	1.79	
Yazoo City	90	35	64.0	1.76	
Missouri.					
Appleton City	88	25	59.0	4.09	
Arthur	89	24	57.8	4.49	
Avalon	85	24	56.6	1.91	
Belle	82[f]	24[f]	57.1[f]	3.94	
Bethany	79	18	52.1	1.75	
Birch Tree	88	25	57.2	3.31	
Bolivar	87	24	59.0	4.00	
Booneville				2.84	
Brunswick	82	24	54.8	2.02	
Caruthersville	91	30	60.2	2.54	
Clinton	85	26	57.2	3.44	
Conception	76	23	53.1	2.41	
Darksville	82	19	54.6	1.68	
Dean	88	26	59.4	2.85	
De Soto	85	26	56.3	4.49	
Doniphan	89[e]	29[e]	57.6[e]	3.87	
Eldorado Springs	89	26	58.6	5.90	
Fairport				2.13	
Farmington	85[e]	28[e]	55.2[e]	1.28	
Fayette	80	22	53.0	2.98	
Fulton	82	24	56.4	2.76	
Gallatin *[1]			56.8	1.76	
Gano	86	24	58.0	3.53	
Goodland	82	24	55.6	4.70	
Gorin				1.34	
Grant City	81	20	54.6	1.91	
Harrisonville	83	25	55.1	3.10	
Hazlehurst				1.13	
Hermann				2.50	
Houston	90	21	57.4	2.04	
Huntsville				2.10	
Ironton	87	23	55.0	4.50	
Jackson	88	28	58.6	3.15	
Jefferson City	82	22	53.8	3.64	
Joplin	86	30	59.5	3.69	
Kidder	82	28	55.1	1.39	
Koshkonong	89[l]	29	60.1[f]	2.86	
Lamar	88	28	59.0	6.44	
Lamonte				2.60	
Lebanon	85	26	56.3	4.67	
Lexington	80	24	56.6	1.79	
Liberty	81	28	56.2	2.02	
Lockwood	88	27	58.8	3.06	
Louisiana	84	20	53.6	2.24	
Marble Hill	91	29	57.1	1.51	
Marshall	81	21	56.0	2.45	
Maryville	81	21	52.8	2.97	
Mexico	84	22	54.4	2.81	
Monroe	84	23	53.9	2.23	
Mountain Grove	85	24	56.8	2.01	
Mount Vernon	94[g]	25[g]	58.6[g]		
Neosho	87	25	58.2	4.38	
Nevada				5.01	
New Madrid				3.16	
New Palestine	84	27	57.4	3.29	
Oakfield	82	26	56.6	2.62	
Olden	90	21	58.4	2.74	
Oregon	78	25	54.5	3.20	
Osceola				3.59	
Princeton	78	22	52.2	0.99	
Rolla	85	25	56.2	2.52	
St. Charles	84	26	55.4	1.82	
Sikeston	90	28	58.2	3.03	
Steffenville	87	21	55.0	1.03	
Sublett	83	18	53.8	1.15	
Trenton	79	22	53.8	0.99	
Unionville	80	18	52.5	2.36	
Versailles	88	27	55.8	3.40	
Warrensburg	84	26	57.8	3.25	
Warrenton	83	25	54.0	1.73	
Warsaw	86	24	56.9	4.62	
Wheatland				3.94	
Willow Springs	90	26	58.2	3.36	
Windsor	86	22	56.8	1.85	
Montana.					
Adel	75	17	49.3	0.53	
Anaconda	74	26	49.8	0.30	
Augusta	80	16	48.6	0.42	
Babb	75[e]	24[e]	49.6[e]	0.34	
Billings	84	25	53.8	0.57	
Bozeman (Agr. College)	75	27	48.0	1.08	
Broadview	84	17	49.6	0.17	T.
***Montana*—Cont'd.**					
Busby	82	14	47.6	0.39	T.
Butte	73	30	49.4	0.20	
Canyon Ferry	75	26	48.2	0.44	
Cascade	82	20	52.4	0.59	
Chester	79	19	48.6	0.00	
Choteau	83	18	51.4	0.05	
Columbia Falls	74	19	46.8	0.36	
Copper				0.63	2.0
Crow Agency	80	22	50.2	0.75	
Dayton	77	28	48.9	0.03	
Decker	80	20	50.0	0.70	
Dillon	80	26	49.7	0.71	
Ekalaka	80	15	50.4	0.08	
Ericson				1.17	
Fallon	84	9	47.8	T.	
Fort Benton	82	27	50.4	0.00	
Fort Shaw	82	21	51.8	0.44	
Fortine	75	20	43.8	0.31	
Glasgow	78	21	47.5	0.00	
Glendive	83	11	49.4	T.	
Gold Butte	73	15	47.0	0.00	
Graham	86[m]	24[m]	50.8[m]	0.02	
Grayling	69[f]	13[f]	41.2[f]	0.81	
Great Falls	75	21	52.4	0.10	
Highwood				0.65	
Huntley	80	22	52.2	0.51	
Jordan	81	16	48.8	0.00	
Lake McDonell	74[j]	22[j]	48.1[j]	0.37	
Lewistown	89	20	49.8	0.26	
Livingston	81	25	53.7	0.65	
Missoula	79			0.19	
Moore				0.28	
Norris	77	30	50.8	1.27	
Nye				0.78	T.
Philipsburg	76	25	48.2	0.62	T.
Plains	73	28	51.6	T.	
Pleasant Valley	79	23	46.8	0.00	
Polson	74	33	50.2	0.00	
Poplar	80	10	48.7	T.	
Raymond	75[j]	20[j]	47.5[j]	T.	
Red Lodge	71	25	46.2	1.13	
Renovo	75	23	48.6	0.89	
Ridge Lawn				T.	
Saltese				0.20	
Snowshoe	69	31	47.0	0.95	3.0
Springbrook	84	12	47.8	0.23	T.
Tokna	85	12	49.1	0.16	
Townsend				0.26	
Tosten	78	22	49.3	0.44	
Troy	71	25	48.4	0.50	
Utica	79	23	51.6	0.20	T.
Wolf Creek	80	25	52.6	0.13	
Nebraska					
Ainsworth	85	21	51.3	0.00	
Alliance				0.01	
Alma	84	25	54.4	0.40	
Anoka	81[n]	20[l]	49.5[l]	T.	
Arapahoe				1.65	
Arcadia				T.	
Ashland	80	24	53.8	1.42	
Ashton				0.01	
Atkinson	85	20	50.4	0.90	
Auburn	82	19	54.4	3.26	
Aurora	82	28	53.0	0.12	
Beatrice	80	23	54.0	1.53	
Beaver	90	29	56.7	0.48	
Bellevue	80			1.05	
Benkleman				T.	
Blair	79	22	53.0	0.86	
Bloomfield	81	18	52.4	0.31	
Blue Hill				0.25	
Bradshaw				2.20	
Bridgeport	83	21	51.1	0.00	
Broken Bow	88	23	51.5	0.46	
Burwell				0.00	
Callaway	91	24	54.8	T.	
Cambridge	90	24	55.7	0.96	
Central City				1.80	
Chester				3.50	
Columbus	82	43	52.5	2.07	
Crete	81	27	55.2	1.68	
Culbertson	90			0.22	
Curtis	85	22	51.4	0.93	
David City	77	27	54.2	1.50	
Dawson	83	21	56.0	2.64	
Du Bois				2.61	
Duff				T.	
Dunning				0.50	
Edgar				1.32	
Ellis				2.81	
Ericson				0.00	
Ewing	80	17	48.6	0.00	
Fairbury	87	25	55.4	1.37	
Fairmont	83	25	51.4	2.90	
Fort Robinson	84	15	49.6	0.09	
Franklin	86[e]	26[e]	55.6[e]	0.33	
Fremont	82	20	52.8	1.20	
Fullerton	82	23	52.4	0.37	
***Nebraska*—Cont'd.**					
Geneva	89	26	54.8	2.10	
Genoa (near)	80	24	53.2	0.42	
Gering				T	
Gosper				0.10	
Gothenburg	95	24	55.2	0.40	
Grand Island	81	30	53.7	1.63	
Grant	88	21	51.4	0.12	
Greeley	81	19	53.6	0.47	
Guide Rock				0.62	
Haigler				0.00	
Halsey	89	23	53.7	T.	
Hartington	83	22	52.6	0.54	
Harvard	79	25	51.6	0.34	
Hastings	81	30	53.9	1.62	
Hayes Center	88	26	55.1	0.08	
Hay Springs	85	9	49.4	T.	
Hebron	83	26	53.8	1.68	
Hendley				0.30	
Holdrege	88	30	58.6	0.67	
Hooper *[1]	80	24	50.6	1.58	
Imperial	88	27	53.2	T.	
Kearney	82	28	53.9	0.43	
Kennedy	82[g]	18[g]	49.4[g]	0.45	
Kimball	80	23	50.8	0.19	
Kirkwood	86	19	52.4	T.	
Leavitt	84	17	51.6	0.63	
Lexington	89	29	55.3	0.60	
Lodgepole	82	30		0.00	
Loup	85	25	52.0	0.10	
Lynch	86	19	53.2	0.48	
McCook				0.50	
McCool				0.63	
Madison	80	21	53.0	0.40	
Marquette				0.86	
Mason City				0.50	
Minden	84	30	53.9	0.84	
Monroe				0.20	
Nebraska City	80	21	54.0	2.67	
Nemaha				1.85	
Norfolk	82	20	51.4	0.51	
North Loup	82	23	52.8	0.00	
Oakdale	82	18	50.4	0.01	
Oakland				1.12	
Odell				2.55	
Ord				0.00	
Palmyra *[1]	80	28	54.5	1.80	
Pawnee City	82	19	54.7	2.49	
Plymouth	84	26	55.0	1.92	
Purdum	85	22	52.9	0.81	
Ravenna	85	26	53.4	0.17	
Redcloud	81[e]	27[e]	55.4[e]	0.51	
Republican				0.55	
St. Libory				0.22	
St. Paul	85	26	54.2	0.35	
Santee	85	28	56.0	T.	
Schuyler				1.92	
Scottsbluff	85	20	49.8	0.04	
Seward	82	20	53.8	0.66	
Springview	84	21	51.1	1.17	
Stanton	80	17	49.8	0.18	
Strang				0.35	
Stratton				0.21	
Superior	82	28	52.2	4.04	
Syracuse				1.70	
Table Rock				2.30	
Tecumseh	82	19	54.4	2.60	
Tekamah	82	18	53.0	1.24	
Turlington	88	27	54.4	2.13	
University Farm	81	21	53.7	1.15	
Wahoo				1.40	
Wakefield	83	15	51.0	0.15	
Watertown				0.37	
Wauneta				0.00	
Weeping Water	81	16	52.5	1.43	
Westpoint	84	16	51.8	0.84	
Wilber				1.80	
Wilsonville				0.20	
Wymore	95	28	59.6	0.95	
York	83	24	54.2	1.72	
Nevada.					
Amos	84	22	53.9	0.51	
Austin	70	29	51.1	0.36	
Battle Mountain	76	30	48.6	1.00	
Beowawe *[5]	80	40	61.3	1.04	
Carson Dam	81	30	56.5	0.39	
Clover Valley	80	26	51.9	0.63	
Columbia	79	32	52.8	2.25	
Elko *[1]	86	33	57.2		
Eureka	73	28	51.0	0.85	1.5
Fallon				0.41	
Fenelon				0.75	
Fernley	82	31	57.0	0.83	
Golconda	80	29	52.2		
Halleck *[1]	80	27	56.8	0.75	
Humboldt	80	37	55.9	0.00	
Jean	91[f]	46[f]	69.8[f]	1.70	
Las Vegas	94	41	66.6	0.46	
Leetville	82	27	55.8	0.80	

TABLE II.—*Climatological record of cooperative observers*—Continued.

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
	°	°	°	*Ins.*	*Ins.*
Nevada—Cont'd.					
Lewers Ranch	80	30	53.0	1.20	T.
Logan	96	45	68.6	1.80	
McAfees Ranch	79	13	45.8	0.24	
Millett	77	24	51.3	1.20	
Mill City*[1]	80	33	55.3	1.06	
Mina	65	31	46.2	0.00	
Palmetto	75	26	48.0	6.93	
Paradise	......	......	......	1.05	
Potts	74	23	46.3	0.80	
San Jacinto	75	20	48.8	0.69	
Soda Lake	84[e]	25[e]	36.8[e]	0.54	
Squaw Valley	78	18	49.8	0.38	
Tecoma	75	29	50.8	0.30	
Wabuska	81	25	52.9	0.66	
Wells*[1]	88	37	64.6	0.00	
New Hampshire.					
Alstead	70	22	43.4	5.64	1.0
Bethlehem	63	15	39.6	4.93	6.0
Brookline	70	18	46.2	4.83	
Durham	73	19	46.2	3.43	
Franklin Falls	75	18	44.7	4.67	
Grafton	70	13	41.8	5.23	T.
Hanover	72	17	43.2	4.65	T.
Keene	75	17	44.4	4.83	T.
Nashua	74	17	45.8	4.04	T.
Newton	72	15	44.6	3.79	
Plymouth	71	16	42.9	5.36	
New Jersey.					
Asbury Park	73	33	51.6	3.27	
Bayonne	73	30	51.2	4.28	
Belvidere	75	25	49.7	4.82	
Bergen Point	75	31	51.2	4.52	
Beverly	77	26	50.6	3.99	
Bridgeton	80	28	52.3	3.51	
Burlington	......	......	......	4.48	
Canton	......	......	......	2.82	
Cape May C. H	74	30	52.4	2.99	
Charlotteburg	76	19	47.2	6.36	
Clayton	76	27	51.1	4.08	
College Farm	76	24	49.6	4.95	
Culvers Lake	......	......	......	6.31	
Dover	74	23	46.7	7.18	
Egg Harbor City	78	30	......	3.25	
Elizabeth	75	29	51.2	3.95	
Englewood	74	32	51.2	4.17	
Flemington	77	25	51.1	4.78	
Friesburg	78	25	50.8	3.60	
Hightstown	74	26	50.4	4.14	
Imlaystown	77	25	50.8	4.11	
Indian Mills	79	23	50.8	4.37	
Jersey City	75	32	52.2	4.45	
Lambertville	76	26	50.0	4.93	
Layton	76	19	46.1	5.06	
Moorestown	76	26	50.8	3.89	
Newark	76	29	51.2	6.07	
New Brunswick	76	24	49.5	4.85	
Oceanic	74	29	51.9	2.92	
Paterson	77	28	51.4	5.80	
Phillipsburg	78	26	50.0	4.63	
Plainfield	74	25	49.2	4.30	
Pleasantville	......	......	......	3.08	
Rancocas	......	......	......	4.03	
Rivervale	75[e]	18[e]	46.4[e]	4.80	
Runyon	......	......	......	3.72	
Somerville	76	23	49.6	4.27	
South Orange	72	29	49.0	5.29	
Sussex	74	25	48.2	6.37	
Toms River	78[e]	......	......	2.70	T.
Trenton	74	29	52.4	2.98	
Tuckerton	73	24	49.8	2.87	
Vineland	79	26	51.2	4.15	
Woodbine	76	25	50.7	3.42	
New Mexico.					
Alamogordo	84	40	60.4	0.84	
Albert	85	30	57.8	0.45	
Albuquerque	84[i]	42[i]	58.0[i]	......	
Alto	......	......	......	3.72	
Bellranch	85	32	57.4	0.82	
Bloomfield	79	28	55.7	0.46	
Cambray	......	......	......	3.01	
Carlsbad	93	39	62.0	8.08	
Chama	79	24	49.1	0.92	
Cimarron	76	27	51.8	0.74	
Clayton	89	28	58.8	0.17	
Cliff	84	31	59.8	2.31	
Cloudcroft	63	22	42.8	4.55	
Deming	91	34	64.2	0.41	
Dorsey	78	28	52.1	0.56	
Dulce	80	22	51.2	0.42	
Eagle Rock Ranch	74	26	49.4	0.69	
Elizabethtown	66	18	41.7	0.60	
Elk	80	33	53.0	5.34	
Estancia	85	25	55.4	1.94	
Fairview	80	30	51.4	2.85	
Fort Bayard	76	36	55.8	1.12	
Fort Stanton	76	24	52.0	2.64	
Fort Union	75	24	49.3	0.70	
Fort Wingate	74	30	48.8	2.00	
New Mexico—Cont'd.					
Fruitland	78	20	52.6	1.30	
Gage	90	37	60.9	1.18	
Glen	94	31	59.8	2.89	
Hillsboro	77	40	57.2	2.03	
Hope	......	......	......	4.05	
Lake Valley	......	......	......	2.31	
Las Vegas	77	25	51.2	0.82	
Logan	89	27	57.8	1.09	
Lordsburg	90	46	65.7	1.20	
Los Alamos	......	......	......	0.70	
Los Lunas	78	32	55.4	1.80	
Luna	......	......	......	3.50	
Magdalena	72	30	51.2	1.89	
Manuelito	......	......	......	2.80	
Mesilla Park	88	35	61.8	0.57	
Mimbre's	......	......	......	1.59	
Mineral Hill	......	......	......	1.35	
Monument	90	38	61.3	8.05	
Mountain Air	75	31	52.2	3.45	
Nara Visa	87	32	57.9	1.51	
Nursery Site	73	28	48.8	1.13	
Orange	90	29	60.0	2.43	
Red River	......	......	......	0.95	5.0
Redrock	......	......	......	1.70	
Rincon	85[e]	34	60.4[e]	1.26	
Rociada	71	20	47.4	0.79	
Rosa	......	......	......	0.33	
Rosedale	69	34	50.6	2.56	
San Jon	83	30	58.9	1.73	
San Marcial[h]	87	31	58.7	......	
San Rafael	76	28	52.2	1.65	
Socorro	85	32	58.8	3.00	
Springer	78	21	51.0	0.15	
Strauss	......	......	......	1.35	
Taos	75	29	51.3	1.24	T.
Tres Piedras	72	22	47.0	0.80	
Tucumcari	......	......	......	1.43	
Valley	......	......	......	T.	
Vermejo	72	24	47.6	2.36	
Winsor	70[k]	20[k]	45.0[k]		
New York.					
Adams	71	24	47.0	5.13	2.5
Addison	84	19	46.9	3.02	T.
Allegany	81	17	45.6	3.81	2.2
Angelica	76	15	43.2	3.46	3.0
Appleton	76	22	46.8	3.54	
Athens	73	25	47.6	5.80	
Auburn	75	22	46.2	6.18	
Avon	77	21	45.8	3.70	
Baldwinsville	75[f]	24[f]	46.8[f]	4.54	
Ballston Lake	73	22	44.8	3.62	
Bedford	74	23	48.1	5.85	
Blue Mountain Lake	......	......	......	5.44	4.0
Bouckville	73	18	42.0	3.66	
Brockport	77	24	46.6	3.63	
Cape Vincent	67	25	47.2	3.60	
Carmel	70	22	45.7	9.43	
Carvers Falls	73	20	43.5	5.34	
Chatham	72	24	47.0	6.82	T.
Cooperstown	70	21	41.8	4.86	
Cortland	75	19	43.9	4.53	
Cutchogue	70	28	51.0	3.59	
Dannemora	68	18	42.6	2.18	0.2
De Ruyter	78	18	44.3	5.25	T.
Easton	......	......	......	4.81	
Elba	74	23	45.2	3.95	
Elmira	75	22	47.2	3.98	
Fayetteville	78	20	46.7	3.21	T.
Fort Plain	74	24	46.0	3.50	
Franklinville	78	14	43.2	3.80	2.0
Glens Falls	73	21	45.1	5.31	
Gloversville	71	20	42.7	4.67	
Greenfield	73	22	43.5	4.40	
Greenwich	71	22	44.8	5.40	
Griffin Corners	74	11	40.8	5.30	5.0
Harkness	70	20	43.3	2.96	3.0
Haskinville	......	......	......	3.45	T.
Hemlock	75	25	46.6	3.36	
Hunt	82	20	48.2	2.95	
Indian Lake	70	10	40.5	4.66	5.0
Ithaca	80	22	46.4	3.52	0.3
Jamestown	81	23	47.0	4.67	T.
Jeffersonville	79	18	45.1	3.58	5.0
Keene Valley	73[e]	18[e]	42.6[e]		
Keuka Park	80	23	46.4	2.90	T.
Kings Ferry	......	......	......	4.19	
Lake George	77	22	44.5	4.73	T.
Le Roy	77	24	45.8	3.36	T.
Liberty	71	20	43.4	5.18	6.0
Little Falls City Res.	72	22	44.0	3.98	T.
Lockport	75	23	46.6	3.13	
Lowville	73	19	42.2	4.25	
Lyndonville	......	......	......	3.49	T.
Lyons	80	25	47.4	5.52	
Middletown	73	28	47.6	6.30	
Mohonk Lake	69	26	45.4	7.22	T.
Moira	69	19	44.1	3.59	2.0
Mount Hope	73	23	48.1	4.33	
New York—Cont'd.					
Newark Valley	......	......	......	4.50	2.0
New Lisbon	70	15	41.2	4.32	T.
North Hammond	72[d]	23[d]	46.7[d]	3.02	
North Lake	75	16	41.7	5.40	
Norwich	74	21	43.4	4.62	
Ogdensburg	71	23	48.0	2.71	T.
Oneonta	79	22	46.5	3.71	T.
Oxford	73	20	44.8	4.50	
Palermo	......	......	......	4.92	
Perry City	77	15	43.4	4.12	T.
Philadelphia	72	20	44.6	3.97	T.
Plattsburg	72	20	44.2	2.70	1.0
Port Jervis	76	22	47.4	5.30	
Rose	75	23	46.6	5.23	
Salisbury Mills	74	24	48.3	7.66	
Saranac Lake	69	14	35.6	4.39	T.
Scarsdale	70	26	49.2	2.97	
Setauket	71	33	51.2	4.01	
Shortsville	77	25	46.8	4.07	
Skaneateles	......	......	......	4.90	
Southampton	68	28	50.4	2.30	
South Canisteo	85	21	45.0	3.43	4.5
Spier Falls	73	17	44.8	5.08	
Taberg	61	18	42.8	5.06	
Ticonderoga	71	22	45.9	6.51	T.
Tolusia	79	23	45.4	5.70	2.0
Wading River	73	20	49.4	3.76	
Wappinger Falls	72	24	47.6	7.47	
Warwick	......	......	......	6.79	
Watertown	72	21	45.0	4.18	T.
Waverly	76	18	46.4	3.27	2.0
Wedgwood	80	22	45.1	3.48	T.
West Berne	77	19	46.2	3.87	T.
Westfield	77	26	47.6	6.85	
Windham	75	18	43.3	3.38	0.5
Youngstown	......	......	......	2.91	T.
North Carolina.					
Banners Elk	76	21	48.2	1.98	
Beaufort	83	40	62.8	1.39	
Brevard	84	25	53.6	1.01	
Brewers	85	27	55.4	1.04	
Buck Spring	69	14	45.4	0.40	
Caroleen	81	31	57.2	1.02	
Chalybeate Springs	84	28	57.4	0.43	
Chapel Hill	84	31	56.8	0.80	
Clinton	80	27	57.9	0.70	
Eagletown	82	29	57.8	1.10	
Edenton	82	30	55.6	1.55	
Fayetteville	80	33	58.2	1.03	
Goldsboro	81	32	57.8	0.78	
Graham	......	......	......	0.78	
Greensboro	85	33	57.0	0.94	
Greenville	......	......	......	0.55	
Henderson	82	32	56.6	0.87	
Hendersonville	77	27	53.5	0.91	
Horse Cove	74	25	53.2	2.19	
Hot Springs	88	28	57.9	1.80	
Kinston	93	29	59.0	0.89	
Lenoir	85	25	53.8	0.70	
Lexington	84	30	56.2	0.58	
Louisburg	81	30	56.4	0.21	
Lumberton	88	33	59.4	0.97	
Manteo	80	33	58.4	1.56	
Marion	83	30	56.2	0.66	
Marshall	82[f]	25[f]	53.0[f]	......	
Moncure	83	29	56.6	0.46	
Monroe	85	25	56.8	0.27	
Morganton	82	26	54.6	0.63	
Mount Airy	85	25	53.9	0.91	
Mount Holly	......	......	......	1.22	
Murphy	......	......	......	1.61	
Nashville	84	28	57.2	0.91	
New Bern	88	24	59.6	0.56	
Patterson	73	25	50.6	0.90	
Pinehurst	87	33	60.4	0.20	
Ramseur	87	27	56.1	0.65	
Randleman	......	......	......	0.71	
Reidsville	86	34	57.4	1.10	
Rockingham	86	30	61.4	0.40	
Salem	83	28	55.4	1.46	
Salisbury	83	......	......	0.83	
Scotland Neck	82	30	58.6	1.60	
Settle	84	24	58.8	1.24	
Sloan	85	32	59.3	0.31	
Snow Hill	83	26	58.2	0.84	
Southern Pines	87	32	60.0	0.15	
Southport	87	37	63.8	1.38	
Stateville	82	26	56.2	1.60	
Tarboro	85	29	59.2	1.33	
Vade Mecum	82	23	52.6	0.85	
Waynesville	79	23	50.6	0.79	
Weldon	86	29	57.6	1.45	
Willard	......	30	......	0.54	
North Dakota.					
Amenia	78	14	44.6	1.35	
Aplin	82	13	46.8	1.13	1.0
Beach	80	9	47.0	0.17	
Bottineau	79	8	43.6	0.27	T.

TABLE II.—*Climatological record of cooperative observers*—Continued.

Stations.	Temperature. (Fahrenheit.)			Precipitation.	
	Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.
North Dakota—Cont'd.	°	°	°	*Ins.*	*Ins.*
Buford	84	7	47.4	0.00	
Cando	81	6	42.0	0.32	
Coal Harbor	82	10	42.9	1.01	5.0
Crosby	82	11	43.5	0.20	
Dickinson	81	10	46.9	0.10	
Donnybrook	80	5	43.3	0.27	
Edgeley	81	13	44.9	0.41	
Edmore	80	8	43.0	0.63	
Ellendale	......	......	......	1.15	
Elbowoods	82	7	45.2	0.95	0.5
Forman	76	16	46.2	1.78	
Fort Yates	84f	16f	46.5f	1.49	
Fullerton	79	14	43.6	1.28	
Gladys	80	12	46.2	0.05	
Glenullen	83	9	44.8	0.99	1.0
Goforth	83	12	47.5	0.68	
Grafton	79	15	46.7	0.93	
Granville	82	7	43.8	0.65	
Hendley	78	8	47.7	0.02	
Hillsboro	75	17	44.0	1.27	
Jamestown	82	11	43.8	1.40	
Kulm	88	13	45.4	0.46	T.
Lakota	78	11	41.8	0.71	T.
Larimore	80	19	50.8	2.27	
Lisbon	80	11	45.2	1.20	
McKinney	81	4	42.0	0.20	
Manfred	80	10	42.6	0.53	T.
Mayville	79	15	44.4	1.06	T.
Medora	83	9	47.4	0.12	
Melville	83j	16j	48.2j	......	
Minot	83	9	43.8	0.62	
Minto	69	15	42.1	0.81	T.
Mott	83	6	45.8	0.43	
Napoleon	81	5	43.0	0.77	
New England	80	4	43.3	T.	T.
New Salem	84	13	45.6	1.26	1.5
Page	79	12	43.6	0.56	
Park River	80	16	43.6	0.79	
Pembina	......	......	......	0.39	
Plaza	80	9	48.3	0.64	1.0
Portal	78i	4	41.1d	0.00	
Power	82	10	45.0	1.35	
Pratt	82d	5d	42.7d		
Steele	77	11	43.8	0.84	......
Towner	81	9	43.2	0.36	
University	76	13	43.2	0.64	
Valley City	80	11	44.5	0.83	
Willow City	80	8	44.2	0.00	
Wishek	78	9	43.8	0.90	
Ohio.					
Akron	79	26	48.2	3.60	T.
Amesville	85	22	50.2	2.57	
Bangorville	81	25	48.2	2.68	
Bellefontaine	80	22	48.6	1.92	
Benton Ridge	81	25	49.0	1.73	
Bladensburg	88	19	46.9	1.62	T.
Bowling Green	82	24	47.6	3.55	
Bucyrus	82	21	46.6	2.30	
Cadiz	80	28	49.1	3.45	
Cambridge	82	23	48.6	2.54	
Camp Dennison	88	25	51.9	3.23	
Canal Dover	80	21	46.1	1.57	
Canton	80	26	47.0	1.96	
Cardington	80	21	48.4	2.14	T.
Circleville	83	24	49.6	2.25	
Clarington	83	28	50.7	3.40	
Clarksville	83	26	51.8	3.44	
Cleveland b	79	31	48.0	4.13	
Coalton	86	21	50.7	2.75	
Columbus	82	24	49.0	1.88	
Dayton	84	25	50.6	2.90	
Defiance	82	23	48.1	2.01	
Delaware	83	21	48.3	1.79	
Demos	81	27	50.7	3.16	
Findlay	85	22	48.4	1.67	
Frankfort	84	24	51.8	1.91	
Fremont	82	27	49.2	4.29	T.
Garrettsville	79	22	46.6	4.37	
Granville	83	24	49.1	2.19	
Gratiot	74	24	47.6	2.59	0.5
Green	85	24	52.4	3.33	
Greenhill	80	20	45.1	1.63	T.
Greenville	82	27	50.6	1.94	
Hedges	85	21	48.6	2.22	
Hillhouse	81	24	47.8	6.93	T.
Hiram	77	27	47.0	4.09	T.
Hudson	83	22	46.3	5.05	
Ironton	86	28	53.8	1.76	
Jacksonburg	80	29	51.8	......	
Kenton	84	24	47.6	1.58	
Killbuck	83	24	47.9	1.38	T.
Lancaster	81	26	50.0	2.03	T.
Lima	82	27	50.4	1.47	
McConnelsville	82	25	49.4	2.10	0.1
Marietta	80	28	50.9	2.04	
Marion	85	22	49.3	3.14	
Medina	81	22	47.8	4.22	
Milfordton	81	20	46.8	0.95	

Stations.	Temperature. (Fahrenheit.)			Precipitation.	
	Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.
Ohio—Cont'd.	°	°	°	*Ins.*	*Ins.*
Milligan	84	20	48.7	2.22	T.
Millport	80	19	46.6	1.24	
Montpelier	81	24	47.6	3.89	
Napoleon	81	25	49.5	2.06	T.
New Alexandria	82	25	49.5	3.10	
New Berlin	80	24g	46.5d	2.48	
New Holland	85	26	50.2	2.48	
New Richmond	84	27	53.6	3.57	
New Waterford	80	21	46.2	1.91	
North Lewisburg	82	22	43.7	2.15	
North Royalton	80	26	47.6	4.38	
Norwalk	83	25	47.5	2.84	
Oberlin	83	23	48.0	3.78	
Ottawa	83	24	49.0	2.03	T.
Pataskala	81	25	48.9	2.64	
Philo	82	27	50.6	1.18	
Plattsburg	81	23	50.2	2.40	
Portsmouth	84	29	52.0	1.73	T.
Pulse	......	......	......	3.32	
Rittman	81	22	47.5	3.28	T.
Rockyridge	84	26	48.4	3.04	T.
Rome	82e	22e	46.9e	4.56	
Shenandoah	81e	23e	45.1e	3.10	
Sidney	85	25	50.2	2.25	
Somerset	81	26	50.2	2.80	
South Lorain	82	22	48.6	4.02	T.
Springfield	......	......	......	2.77	
Summerfield	81	22	48.4	2.90	0.2
Thurman	85	25	52.7	2.19	
Tiffin	79	28	48.2	2.50	
Toledo (St. Johns College)	81	28	48.9	2.51	
Upper Sandusky	81	24	48.8	2.24	
Urbana	84	20	49.9	1.94	
Vickery	83	24	46.9	4.70	
Warren	83	23	47.5	3.05	
Wauseon	83	22	46.8	2.63	
Waverly	88	23	52.0	2.12	
Waynesville	81	28	50.2	3.25	
Wellington	82	24	48.2	4.24	
Willoughby	......	......	......	5.21	
Wilson	86	22	50.7	2.58	
Wooster	82	22	47.4	2.34	
Zanesville	......	......	......	1.87	
Oklahoma.					
Alva	89	36	58.9	5.10	
Arapaho	92	36	62.0	6.48	
Buffalo	91	30	60.2	2.95	
Cache	89	33	60.3	6.37	
Chandler	94	32	62.0	2.33	
Chattanooga	91	38	63.0	9.20	
Cloud Chief	94	37	62.6	5.94	
Dacoma	91	36	60.3	7.47	
Eldorado	92	38	63.2	4.14	
Erick	88	35	60.6	5.73	
Fort Sill	91	46	65.4	5.35	
Frederick	94	45	68.3	6.25	
Gage	89	32	58.2	2.41	
Grand	88	31	60.8	3.54	
Guthrie	91	35	62.6	5.60	
Harrington	84	34	58.5	4.44	
Hennessey	91	36	62.2	6.64	
Hobart	93	39	62.8	6.38	
Hooker	92	31	57.4	1.02	
Jefferson	90	35	60.0	6.55	
Kenton	85	23	57.0	0.50	
Kingfisher	82	36	61.4	4.78	
McComb	86	36	61.8	3.26	
Mangum	90	40	62.3	4.90	
Meeker	91	31	61.0	2.65	
Mutual	86	34	57.7	3.63	
Neola	92	38	62.6	4.96	
Newkirk	90	35	61.0	5.57	
Norman	91l	41l	65.3l	......	
Okeene	92	38	62.2	7.00	
Pawhuska	90	32	60.8	4.83	
Perry	90	33	61.4	5.98	
Sac and Fox Agency	89	34	62.7	1.91	
Shawnee	88	35	62.0	3.81	
Snyder	91	38	63.2	5.32	
Stillwater	90	34	60.0	5.14	
Temple	......	40	......	4.80	
Watonga	90	36	60.4	1.53	
Waukomis	91	36	61.7	7.93	
Weatherford	90	37	61.0	5.05	
Whiteagle	90	35	61.4	5.02	
Oregon.					
Alba	......	......	......	0.79	
Albany	82	36	56.4	1.21	
Ashland	85	40	59.1	1.03	
Astoria	81	43	59.0	1.08	
Aurora (near)	81	39	55.2	1.55	
Bay City	89	38	57.8	2.84	
Bend	86	24	52.2	0.40	
Black Butte	78	35	55.4	2.57	
Blalock	88	43	62.2	0.14	
Buckhorn	89	55	57.9	1.33	
Bullrun	79	40	55.0	1.99	
Burns	81	27	54.4	0.27	

Stations.	Temperature. (Fahrenheit.)			Precipitation.	
	Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.
Oregon—Cont'd.	°	°	°	*Ins.*	*Ins.*
Cascade Locks	80	43	57.6	1.62	
Coquille	......	......	......	2.14	
Corvallis	81	35	56.2	1.32	
Dayville	88	28	55.0	0.57	
Doraville	80	41	54.1	1.71	
Drain	85	41	58.2	1.43	
Echo	88	34	58.0	0.36	
Ella	79	30	56.2	0.11	
Eugene	77	40	55.9	1.33	
Fairview	95	40	54.5	3.42	
Falls City	86	......	......	1.01	
Glendale	91	39	58.6	1.23	
Glenora	78	34	55.5	3.28	
Gold Beach	90	38	55.1	3.78	
Granite	81	21	49.4	0.30	T.
Grants Pass	92	33	58.6	1.29	
Grass Valley	75	......	......	0.20	T.
Heisler	88	25	53.8	0.20	
Heppner	85	37	56.3	0.47	
Hood River	84	33	55.1	0.37	
Huntington	85	30	56.4	0.01	
Jacksonville	90	37	59.9	0.92	
Joseph	83	29	53.4	1.00	
Klamath Falls	89	31	58.4	0.67	
La Grande	85	29	54.8	0.33	
Lakeview	89	29	53.1	2.85	
Lost River	80	22	52.2	0.90	
McKenzie Bridge	88	31	55.6	2.03	
Marshfield	91	34	56.6	2.42	
Monroe	80	40	56.3	1.14	
Mountain Park	77	35	55.1	1.09	
Mount Angel	83	41	56.3	1.20	
Nehalem	......	......	......	2.56	
Newport	90	44	55.9	1.63	
Olex (near)	85	38	57.0	0.10	
Ontario	......	......	......	0.62	
Orseco	77c	32c	52.2c	2.97	
Pendleton	85	33	54.8	0.68	
Pompeii	74	32	52.8	1.81	T.
Port Orford	86	47	56.2	3.92	
Prineville	83	20	51.8	0.26	
Richland	86	28	57.5	0.30	
Riverside	82	25	53.7	0.74	
Salem	79	78	56.8	0.86	
Silver Lake	80	22	50.0	0.77	
Stafford	83	41	56.3	1.54	
The Dalles	81	37	57.6	0.29	
Toledo	88	40	57.8	2.10	
Umatilla	90	37	61.2	0.14	
Vale	85	28	55.0	0.58	
Wallowa	83	22	51.8	0.44	
Wamic	85k	29j	53.0k	......	
Warm Spring	88	26	54.5	0.20	
Wasco	......	......	......	0.29	
Weston	87	37	57.2	1.43	
Williams	90f	34f	59.7f	......	
Yonna	82	18m	51.3g	1.63	
Pennsylvania.					
Aleppo	81	22	48.0	3.64	
Altoona	77d	20d	46.2d	1.80	
Baldwin	76	24	47.2	2.41	T.
Beaver Dam	......	......	......	2.43	
Bellefonte	80	24	49.7	2.60	
Browers Lock	......	......	......	5.13	
California	82	26	51.2	1.96	
Cassandra	75	21	44.8	3.19	T.
Center Hall	76	24	49.3	1.88	
Clarion	......	......	......	3.82	
Claysville	82	21	48.2	2.84	T.
Coatsville	80	25	50.7	3.04	
Confluence	......	......	......	2.24	
Davis Island Dam	......	......	......	2.44	
Derry	84	21	50.5	2.67	
Doylestown	......	......	......	4.92	
Drifton	74	22	46.2	1.98	
Dushore	76	19	43.7	3.80	T.
East Mauch Chunk	83	22	48.5	3.91	
Easton	74	27	48.8	4.28	
Ellwood Junction	......	......	......	2.39	
Emporium	78	20	46.2	3.60	0.4
Ephrata	77	22	49.3	3.01	
Everett	82	20	48.6	1.01	
Forks of Neshaminy	......	......	......	4.86	
Franklin	79	20	46.7	3.78	
Freeport	81f	23f	48.4f	2.81	
George School	76	25	50.1	4.77	
Gettysburg	73	25	48.4	2.25	
Girardville	......	......	......	3.84	
Gordon	77	20	46.0	4.27	
Greensboro	......	......	......	2.82	
Greenville	79	22	46.2	3.71	
Grove City	76	22	47.3	2.46	
Hamburg	82	26	50.0	3.80	
Hanover	77	25	52.0	2.91	
Herrs Island Dam	......	......	......	1.94	
Huntingdon	80	21	48.0	2.19	
Hyndman	82	22	48.2	1.47	
Indiana	78	22	48.3	3.15	

TABLE II.—*Climatological record of cooperative observers*—Continued.

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Pennsylvania—Cont'd.	°	°	°	Ins.	Ins.
Irwin	82	21	50.6	2.36	
Johnstown	81	25	49.7	2.65	
Lansdale	.....	.....	.....	3.02	
Lawrenceville	83	19	45.8	3.15	T.
Lebanon	75	26	50.2	3.07	
Le Roy	77	24	45.6	3.40	2.0
Lewisburg	81	24	49.5	2.86	
Lock Haven	81	23	48.4	2.42	
Lock No. 4	.....	.....	.....	2.01	
Lycippus	76	28	49.6	2.89	T.
Marion	79	24	49.8	1.36	
Mauch Chunk	.....	.....	.....	3.91	
Mifflintown	77	21	47.4	1.98	
Milford	76	20	46.2	4.67	
Montrose	78	15	44.8	3.87	.....
New Germantown	79	21	48.4	2.22	
Ottsville	.....	.....	.....	4.49	
Philadelphia	75	34	53.8	3.18	
Pocono Lake	74	13	41.5	4.35	
Point Pleasant	.....	.....	.....	5.64	
Pottsville	.....	.....	.....	4.34	
Reading	77	26	50.6	3.40	
Renovo	.....	.....	.....	2.84	
Saegerstown	81	20	45.6	4.56	T.
St. Marys	87	21	47.6	3.77	0.5
Saltsburg	.....	.....	.....	2.70	
Seisholtzville	.....	.....	.....	4.27	
Selinsgrove	79	24	48.4	3.86	
Shawmont	.....	.....	.....	4.59	
Skidmore	80	20	47.0	2.18	
Smiths Corners	.....	.....	.....	5.54	
Somerset	77	20	45.6	1.77	
South Eaton	76	23	47.6	3.86	
Springdale	.....	.....	.....	2.82	
Springmount	.....	.....	.....	3.66	
State College	77	24	46.6	2.91	
Towanda	81	23	46.4	3.12	0.5
Uniontown	80	20	49.2	3.08	
Warren	76	22	45.2	3.82	
Wellsboro	82	19	45.8	2.76	T.
West Chester	78	28	51.4	4.62	
West Newton	.....	.....	.....	2.00	
Wilkes-Barre	80	24	49.3	2.50	
Williamsport	75	26	48.8	2.14	
Rhode Island.					
Bristol	65	29	50.1	2.41	
Kingston	68	24	47.7	3.06	
Providence	.....	.....	.....	3.76	
South Carolina.					
Aiken	86	28	62.6	0.00	
Allendale	87	36	63.8	0.76	
Anderson	85	32	60.3	1.14	
Batesburg	82	33	60.2	0.06	
Beaufort	85	40	65.2	2.32	
Bennettsville	85	34	60.6	0.29	
Blackville	88	33	63.2	0.50	
Blairs	.....	.....	.....	0.50	
Bowman	87	31	62.8	0.49	
Calhoun Falls	.....	.....	.....	0.98	
Camden	83	29	60.0	0.46	
Catawba	.....	.....	.....	0.90	
Chappells	.....	.....	.....	0.90	
Cheraw	85	33	58.8	0.34	
Clarks Hill	88	30	60.8	0.43	
Clemson College	78	34	57.2	1.58	
Conway	87	35	61.5	0.77	
Darlington	87	34	60.6	0.17	
Dillon	89	.....	60.2	0.85	
Edisto	.....	.....	.....	1.01	
Effingham	.....	.....	.....	1.00	
Florence	89	35	61.6	0.55	
Georgetown	90	39	62.6	0.80	
Greenville	80	31	55.7	1.27	
Greenwood	81	34	59.6	1.25	
Heath Spring	83	37	62.1	0.56	
Kingstree	85	36	62.4	0.15	
Liberty	82	32	58.5	1.32	
Newberry	85	32	60.9	0.56	
Pelzer	.....	.....	.....	1.30	
St. George	86	35	62.8	0.44	
St. Matthews	82	36	60.4	0.25	
Saluda	90	29	60.8	0.35	
Santuck	83	31	59.4	1.16	
Smiths Mills	.....	.....	.....	0.24	
Society Hill	82	36	59.0	0.48	
Spartanburg	87	32	59.4	1.15	
Statesburg	84	36	62.2	0.87	
Summerville	88	34	63.5	0.97	
Trenton	83	35	61.0	0.68	
Trial	86	31	61.5	0.60	
Walhalla	87	30	62.6	1.85	
Walterboro	91	33	64.8	0.85	
Winnsboro	85	35	61.1	0.52	
Winthrop College	79	34	58.7	0.82	
Yemassee	84	34	60.2	2.10	
Yorkville	84	35	61.2	0.70	
South Dakota.	°	°	°	Ins.	Ins.
Aberdeen	80	16	45.8	1.33	
Academy	84	22	52.6	1.26	
Alexandria	80	18	50.0	0.10	
Armour	87	19	50.4	0.05	
Ashcroft	88	16	50.1	T.	
Bowdle	80	16	47.4	1.35	
Brookings	87	15	47.3	0.96	
Canton	82	15	48.9	0.46	
Castlewood	84	13	45.9	0.95	
Centerville	80	20	49.7	0.16	
Chamberlain	89	20	51.5	1.18	T.
Cherry Creek	87	16	49.8	0.72	
Clark	86	14	46.6	1.17	
De Smet	89	17	48.2	0.90	
Farmingdale	.....	.....	.....	0.04	
Faulkton	80	16	46.8	1.70	
Flandreau	80	15	46.0	0.73	
Forestburg	88	12	47.8	T.	
Fort Meade	85	10	51.8	0.00	
Frederick	81	11	43.9	0.60	
Gannvalley	87	20	50.6	0.07	
Greenwood	86	21	53.6	0.22	
Hermoso	84	18	50.6	T.	
Highmore	85	18	48.5	1.96	
Howard	86	13	48.0	0.21	
Howell	83	15	46.0	1.67	
Ipswich	80	15	46.0	1.73	
Kidder	83	9	45.2	2.55	
Kimball	86	18	50.0	1.26	
La Delle	85	13	47.1	0.98	
Marion	89	20	51.4	T.	
Mellette	84	13	46.4	2.14	
Menno	83	17	50.0	0.03	
Mill Bank	83	13	45.8	0.91	
Mitchell	84	16	48.2	0.23	
Mound City	82	16	47.8	1.32	
Oelrichs	87[f]	13[f]	48.8[f]	.....	
Orman	82	16	49.8	T.	
Ramsey	83	13	46.4	0.10	
Redfield	84	14	45.0	1.48	
Rosebud	.....	12	.....	0.10	
Roslyn	81	18	45.5	1.26	
Selby	79	15	47.2	0.90	
Sioux Falls	79	21	49.4	0.33	
Spearfish	78	24	50.2	T.	
Stephan	86	11	47.9	1.44	
Vermillion	83	21	52.2	0.18	
Watertown	79	14	43.6	1.36	
Wentworth	85	18	48.2	0.44	
Wessington Springs	83	20	50.0	0.19	
Woolsey	.....	.....	.....	0.97	
Tennessee.					
Arlington	90	32	58.4	3.37	
Ashwood	88	28	58.0	1.57	
Benton	83	29	57.4	1.30	
Birds Bridge	.....	.....	.....	1.28	
Bluff City	.....	.....	.....	2.00	
Bolivar	88	31	57.8	2.94	
Brownsville	89	32	59.2	4.37	
Byrdstown	83	23	56.4	3.28	
Carthage	88	28	60.0	2.88	
Cedar Hill	88	30	58.7	2.60	
Celina	.....	.....	.....	4.56	
Chatt High School	83	37	61.2	1.17	
Clarksville	88	30	57.6	2.57	
Covington	90	32	59.8	3.60	
Dandridge	.....	.....	.....	1.36	
Decatur	84	28	57.6	1.52	
Dickson	90	27	59.0	2.53	
Dover	93	31	57.9	4.41	
Dyersburg	90	34	59.2	4.20	
Elizabethton	82	30	56.2	1.34	T.
Erasmus	81	24	52.8	3.54	
Florence	85	30	57.8	2.11	
Franklin	83	29	56.4	1.49	
Halls Hill	.....	.....	.....	1.95	
Harriman	83	.....	.....	1.50	
Hohenwald	87	26	57.5	1.77	
Iron City	86	26	58.2	1.20	
Jackson	90	31	61.6	3.76	
Johnsonville	89	27	58.2	2.75	
Jonesboro	79	28	54.8	2.47	
Kenton	92	30	60.5	3.87	
Kingston	.....	.....	.....	1.60	
Lafayette	85	23	56.4	3.79	
Lewisburg	87	27	58.4	1.47	
Loudon	.....	.....	.....	1.40	
Lynnville	83	32	57.4	2.19	
McGee	.....	.....	.....	1.23	
McMinnville	85	29	57.6	1.93	
Maryville	83	29	56.9	1.45	
Milan	89	31	56.8	2.66	
Newport	77	29	55.0	1.47	
Palmetto	87	29	58.8	1.69	
Pinewood	89	26	57.8	.....	
Pope	92[h]	27[h]	60.2[h]	.....	
Rogersville	83	29	55.8	1.60	
Rugby	83	21	52.4	1.75	
Tennessee—Cont'd.	°	°	°	Ins.	Ins.
Savannah	88[c]	28[c]	58.4[c]	2.16	
Sevierville	89	24	56.4	1.38	
Sewanee	79	31	56.6	1.45	
Silver Lake	72	24	49.2	2.48	
Sparta	84	28	56.5	1.45	
Springdale	84	24	56.2	2.01	
Springville	87	28	57.5	3.72	
Tazewell	.....	.....	.....	2.23	
Tellico Plains	85	29	58.0	1.75	
Trenton	91	28	58.8	4.26	
Tullahoma	85	27	56.6	1.74	
Union City	88[h]	29[h]	57.2[h]	.....	
Walling	.....	.....	.....	2.15	
Waynesboro	85	27	57.7	1.76	
Wildersville	84	30	57.8	4.53	
Texas.					
Albany	96	43	67.4	6.00	
Alvin	.....	.....	.....	13.00	
Austin	.....	.....	.....	3.67	
Ballinger	93	43	66.1	6.69	
Barstow	81	46	64.0	5.55	
Beaumont	.....	.....	.....	7.66	
Beeville	99	49	75.4	1.26	
Big Spring	92	42	63.0	11.87	
Blanco	95	43	68.3	4.13	
Boerne	91	42	66.4	7.95	
Bonham	93	38	65.0	5.69	
Booth	.....	.....	.....	7.30	
Bowie	95	44	66.6	7.49	
Brazoria	92	49	73.8	9.14	
Brenham	.....	48	.....	7.31	
Brighton	90	55	76.7	1.28	
Brownwood	95	45	67.1	4.16	
Brownsville	94	59	78.6	0.78	
Canadian	85	30	59.2	1.61	
Carmona	93	34	68.2	8.04	
Channing	89	29	60.2	0.90	
Childress	92	39	63.9	3.95	
Chillicothe	.....	.....	.....	6.60	
Clarendon	92	36	60.6	5.24	
Clarksville	92	40	68.4	4.12	
Claude	.....	.....	.....	5.50	
Claytonville	84	35	65.6	5.26	
Coleman	91	49	67.5	5.62	
College Station	97	46	70.6	5.43	
Colorado	94	37	65.0	6.63	
Corsicana	93	44	68.2	4.28	
Crockett	92	43	69.0	5.95	
Cuero	91	52	70.7	4.63	
Dalhart	87	29	58.6	1.01	
Dallas	96	43	66.4	2.71	
Danevang	95	40	73.1	7.78	
Decatur	.....	.....	.....	2.69	
Denison	.....	.....	.....	11.38	
Dialville	89[c]	44[c]	65.5[c]	6.42	
Dublin	92	48	65.8	3.41	
Duval	95	50	69.7	6.06	
Eagle Pass	100	47	72.6	4.61	
Encinal	.....	.....	.....	2.06	
Earls Ranch	.....	.....	.....	5.85	
Falfurrias	100	52	78.0	1.60	
Fort Clark	93	49	71.2	10.34	
Fort Davis	89	.....	.....	3.46	
Fort McIntosh	100	45	76.0	1.05	
Fredericksburg	92	45	67.0	4.32	
Gainesville	95	.....	.....	8.18	
Gatesville	94	45	67.4	5.98	
Georgetown	98	44	70.0	6.98	
Gonzales	.....	.....	.....	3.67	
Graham	.....	.....	.....	3.58	
Grapevine	97	33	67.8	5.50	
Greenville	95	31	66.5	4.17	
Hallettsville	92	52	72.8	9.00	
Hebbronville	.....	.....	.....	2.75	
Hempstead	.....	.....	.....	7.82	
Henrietta	100	43	65.6	4.86	
Hereford	95	29	58.1	4.35	
Hondo	95	51	73.1	7.42	
Houston	93	48	71.6	9.89	
Hubbard	92	45	68.0	7.24	
Huntsville	93	43	67.5	7.94	
Jewett	90	41	67.3	9.34	
Kaufmann	93	44	67.1	4.46	
Keene	97	46	67.2	5.66	
Kerrville	94	40	68.5	6.41	
Knickerbocker	94	39	65.7	4.68	
Kopperl	.....	.....	.....	5.73	
Lampasas	95	43	65.8	5.50	
Liberty	94	41	69.7	6.85	
Llano	96	51	69.8	3.90	
Lone Star Ranch	.....	.....	.....	3.40	
Longview	94	42	66.2	4.09	
Lufkin	93	34	68.5	5.36	
Luling	95	49	71.4	4.96	
McLean	86	35	59.0	3.35	
Marfa	.....	.....	.....	3.63	
Mexia	94	44	66.5	8.67	
Miami	85	24	57.8	2.05	

TABLE II.—*Climatological record of cooperative observers*—Continued.

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Texas—Cont'd.	°	°	°	*Ins.*	*Ins.*
Mobeetee	......	......	......	3.10	
Mount Blanco	90	35	59.8	5.81	
Nacogdoches	94	37	67.2	6.44	
Nazereth	87	31	57.7	4.68	
New Braunfels	94	51	71.6	6.24	
Ochiltree	......	......	......	1.58	
Paris	85	42	65.6	3.14	
Pierce	85	48	68.0	6.20	
Plemons	90	25	57.0	1.76	
Port Lavaca	91	50	74.4	11.67	
Quanah	95	41	65.6	3.22	
Riverside	......	......	......	7.45	
Rock Island	94	42	71.1	5.90	
Rockland	......	......	......	6.72	
Rossville	......	......	......	1.74	
Runge	......	......	......	1.52	
Sabinal	99	49	73.9	7.06	
San Angelo	96	42	66.1	5.15	
San Marcos	94	47	70.4	3.88	
San Saba	93	43	67.0	5.58	
Santa Gertrudes	......	......	......	1.17	
Seymour	95	40	64.8	5.77	
Sherman	92	42	67.4	8.85	
Sonora	92	38	66.4	6.20	
Sugarland	92	45	71.6	9.37	
Sulphur Springs	92	42	66.2	5.15	
Temple	95	50	67.4	5.79	
Tulia	......	......	......	5.25	
Victoria	94	52	73.8	10.48	
Waco	94	49	67.9	6.23	
Waxahachie	97	39	65.8	2.77	
Wharton	92	48	72.0	5.40	
Wichita Falls	95	40	64.4	4.32	
Wills Point	93	41	65.8	8.74	
Utah.					
Alpine	......	......	......	2.21	
Aneth	85[k]	40[k]	64.1[k]	......	
Beaver	76	26	51.2	1.99	
Castle Dale	74	20	49.8	1.63	
Cedar City	75	32	53.1	3.24	6.0
Corinne	86	36	57.6	1.31	
Coyoto	75	17[f]	45.0[f]	2.20	
Deseret	81	25	54.3	0.60	
Emery	78	30	53.4	1.83	
Escalante	73	28	52.4	2.70	
Experiment Farm	88	37	62.4	......	
Farmington	75	30	54.6	1.07	
Fillmore	84	33	57.4	1.99	
Government Creek	76	31	53.8	1.53	
Grantsville	......	......	......	0.96	
Grayson	75	32	53.4	1.59	
Heber	81	25	50.6	1.03	
Henefer	82	24	50.6	1.05	
Hite	86	39	64.0	0.62	
Huntsville	......	......	......	1.95	
Kanosh	......	......	......	1.41	
Kelton	75	33	53.3	0.57	
Levan	74	29	52.0	1.11	
Loa	65	20	43.4	0.75	
Logan	76	36	55.0	1.45	
Lucin	70	19	37.7	0.40	
Marysvale	77	24	51.2	1.97	
Meadowville	69	27	46.1	1.12	
Milford	78	25	51.8	......	
Millville	......	......	......	1.39	
Minersville	......	......	......	1.86	
Moab	83	31	58.6	0.68	
Morgan	84[e]	27[e]	53.3[e]	1.16	
Mount Nebo	74	32	44.0	0.76	
Nephi	......	......	......	0.67	
Oak City	80	24	55.6	0.69	
Ogden	76	37	56.0	1.26	
Parowan	77	28	50.6	2.16	......
Park City	75	28	47.6	2.00	
Payson	......	......	......	1.45	
Pinto	72	25	48.4	3.09	
Plateau	82	27	49.4	1.55	T.
Provo	77	32	53.8	1.20	
Ranch	73	23	48.6	3.41	
Randolph	......	......	......	0.54	
Richfield	83[e]	18[e]	50.2[e]	4.50	3.5
St. George	90	40	63.6	2.09	
Saltair	75	30	50.4	1.00	
Scipio	83	22	53.2	1.35	
Silver Lake	76	23	45.2	2.62	4.0
Snowville	82	26	51.6	0.65	
Soldier Summit	76	20	47.6	......	
Springdale	84	42	63.4	2.62	
Sunnyside	......	......	......	0.55	
Theodore	78[k]	32[k]	54.0[k]	0.53	
Tooele	78	37	55.8	1.85	
Tropic	76	27	51.2	2.97	
Trout Creek	80	27	53.4	0.52	
Verdure	......	......	......	2.00	
Woodruff	80	21	47.8	0.61	
Vermont.					
Bloomfield	67	11	39.6	4.97	0.5
Cavendish	72[f]	16[f]	43.2[f]	4.80	

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Vermont—Cont'd.	°	°	°	*Ins.*	*Ins.*
Chelsea	67	18	39.8	5.75	2.0
Cromwall	69	22	43.6	3.39	
Enosburg Falls	78	18	43.0	4.56	1.0
Jacksonville	62	20	38.4	5.40	1.0
Manchester	69	20	42.8	4.95	T.
St. Johnsbury	71	18	42.2	5.06	1.2
Wells	68	16	41.8	4.78	1.0
Woodstock	66	16	40.0	4.16	
Virginia.					
Arvonia	85	24	53.0	1.26	T.
Ashland	84	30	54.4	2.53	
Bigstone Gap	76	29	53.8	2.76	
Blacksburg	83	21	48.8	1.13	T.
Burkes Garden	73	16	45.6	2.03	T.
Callaville	78	28	56.3	1.01	
Charlottesville	85	33	55.2	0.88	
Clarksville	......	......	......	1.20	
Columbia	80	28	51.9	1.58	
Culpeper	80	27	51.4	1.17	
Dale Enterprise	81	23	49.6	0.73	
Danville	......	......	......	0.92	
Dinwiddie	89	21	53.4	1.71	
Doswell	84	26	54.6	2.44	
Elk Knob	75	30	53.9	2.11	
Fredericksburg	83	27	53.0	1.94	
Galax	78	22	50.1	......	
Hampton	79	39	58.2	1.68	
Hot Springs	75	25	47.2	0.93	
Ivanhoe	......	......	......	0.84	
Lexington	80	25	51.2	0.71	
Lincoln	85	22	52.4	1.05	
Marion	78	24	51.6	1.01	
Max Meadows	75[j]	22[j]	48.6[j]	......	
Newport News	81	38	58.0	1.84	
Nokesville (near)	81	29	52.6	1.58	
Petersburg	84	30	56.7	2.52	
Quantico	79	25	51.5	1.63	
Radford	......	......	......	1.14	
Roanoke	83[g]	28[g]	54.8[g]	......	
Rocky Mount	82	28	53.3	0.64	
Saxe	......	......	......	1.56	
Shenandoah	......	......	......	0.93	
Speers Ferry	......	......	......	1.96	
Spottsville	80	28	55.2	1.81	
Staunton	82	29	53.0	0.68	
Stephens City	83	23	51.8	1.23	
Warsaw	81	27	53.2	3.13	
Williamsburg	82	30	56.8	2.45	
Woodstock	83	26	51.4	0.90	
Washington.					
Aberdeen	80	32	55.0	2.34	
Anacortes	62	35	51.4	0.79	
Baker	80	37	56.0	1.41	
Bellingham	66	32	51.5	2.50	
Blaine	67	32	50.2	1.80	
Cedar River	......	......	......	1.38	
Centralia	77	35	54.4	0.83	
Cheney	90	34	58.4	0.32	
Clearbrook	75	30	51.7	2.70	
Cle Elum	80	22	50.8	0.29	
Colfax	80[j]	29[j]	53.6[j]	......	
Coleville	77	21	49.3	0.51	
Conconully	77	33	52.6	0.14	
Coupeville	79	38	52.7	0.24	
Crescent	78	28	50.9	0.29	
Cusick	77	27	50.1	0.85	
Dayton	80	34	55.5	0.62	
Detroit	69	39	53.4	1.17	
Ellensburg	78	26	52.4	0.29	
Ephrata	82	32	57.9	0.00	
Gardena	89	32	57.3	0.57	
Granite Falls	......	......	......	0.80	
Hatton	87	26	57.2	0.09	
Huntsville	......	......	......	0.65	
Kennewick	86	36	57.0	0.18	
Kiona	86	32	57.4	0.06	
Kosmos	85	37	56.3	2.14	
Lacenter	79	38	53.0	1.44	
Lakeside	79	41	57.1	0.12	
Lester	84	32	56.2	1.05	T.
Mottinger Ranch	91	40	60.4	0.21	
Mount Pleasant	77	43	56.4	1.52	
Moxee	88	27	56.0	0.30	
Northport	71	24	47.0	0.73	
Olga	66	39	52.0	0.71	
Olympia	72	39	53.5	0.99	
Pinehill	83	36	57.2	0.41	
Pomeroy	85	34	56.8	0.14	
Port Townsend	68	40	52.0	0.19	
Pullman	82	36	57.0	0.67	
Quiniault	76	40	54.8	3.89	
Rattlesnake	78	31	55.6	0.25	
Ritzville	......	......	......	0.17	
Rock Lake	......	......	......	0.45	
Rosalia	78	29	53.1	0.62	
Sedro-Woolley	69	35	51.4	1.03	
Sixprong	83	35	58.6	0.22	
Snohomish	70	40	51.4	0.90	

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Washington—Cont'd.	°	°	°	*Ins.*	*Ins.*
Snoqualmie	75	38	52.4	1.59	
South Bend	82	41	61.5	......	
Stehekin	77	34	50.4	0.45	
Sunnyside	86	30	54.1	0.27	
Twisp	83	29	52.5	0.12	
Vancouver	82	39	56.6	0.68	
Vashon	67	41	52.2	0.74	
Wahluke	85[e]	31[e]	55.9[e]	0.20	
Waterville	79	31	53.1	0.12	
Wenatchee (near)	80	36	56.8	0.12	
Westport	......	......	......	2.32	
Wilbur	80	24	53.4	0.48	
Winthrop	80	35	56.9	0.26	
Yale	88	35	57.2	2.63	
Zindel	94	40	62.9	0.66	
West Virginia.					
Bancroft	85	30	52.8	2.35	
Bayard	75	19	44.2	3.82	T.
Beckley	79	13	45.6	3.38	0.5
Bens Run	82	31	51.7	3.41	1.0
Burlington	84	20	49.5	0.60	
Cairo	84[g]	25[g]	53.6[g]	......	
Central Station	81	22	48.8	2.50	T.
Charleston	80	35	54.2	3.10	
Creston	82	20	49.5	2.44	
Cuba	84	24	50.2	3.21	T.
Davis	......	......	......	4.00	
Doane	87	29	54.3	2.72	
Elkhorn	79	28	52.8	3.19	0.5
Fairmont	79	25	49.2	2.59	
Franklin	81	25	49.0	1.02	
Glenville	83	27	49.8	2.36	T.
Grafton	80	24	49.6	4.09	
Green Sulphur Springs	81	20	51.2	1.92	
Harpers Ferry	......	......	......	0.54	
Hinton	80[e]	34[e]	53.4[e]	......	
Huntington	85	29	52.2	2.02	
Leonard	76	29	46.5	3.40	
Lewisburg	80	25	49.2	1.49	T.
Logan	85	36	56.0	4.68	
Lost City	78	26	49.6	1.19	
Lost Creek	81	23	49.0	2.34	
Madison	85	32	53.0	3.38	
Mannington	81	23	49.5	2.57	
Martinsburg	80	24	50.6	1.30	
Moorefield	85	21	49.6	0.90	
Morgantown	80	25	49.7	3.44	
Moundsville	80	26	51.0	3.02	
New Cumberland	......	......	......	3.10	
New Martinsville	84	29	52.2	2.98	
Nuttallburg	......	......	......	2.95	1.0
Oceana	82	31	54.0	2.56	
Parsons	79	22	48.0	3.79	
Philippi	80	23	48.4	3.67	T.
Pickens	76	23	46.4	4.71	1.0
Point Pleasant	84	30	52.6	1.82	
Powellton	84	31	53.7	1.98	
Princeton	76	22	47.4	2.30	1.0
Romney	83	20	48.0	1.20	
Rowlesburg	......	......	......	4.30	
Ryan	81	24	49.2	2.34	
Smithfield	76	27	49.1	2.73	
Southside	82	27	50.3	1.09	
Spencer	80	23	44.5	2.35	
Terra Alta	64	23	47.1	4.73	T.
Union	78	20	48.4	0.57	T.
Uppertract	81	23	49.6	1.01	
Valley Fork	80	30	54.0	3.85	T.
Webster Springs	84	29	51.7	5.12	T.
Wellsburg	76	28	48.2	1.97	
Weston	76[e]	26[e]	46.6[e]	3.22	T.
Wheeling	......	......	......	3.22	
Williamson	......	......	......	2.59	
Wisconsin.					
Amherst	75	18	48.0	0.21	
Antigo	72	18	47.5	0.45	
Appleton	76	20	47.0	0.49	
Appleton Marsh	75	17	45.3	0.59	T.
Ashland	72	23	46.0	0.52	T.
Beloit	78	26	48.3	0.88	
Brodhead	82	22	48.5	1.25	
Burnett	76	23	46.6	1.08	T.
Butternut	72	13	40.8	0.16	0.1
Cecil	76[e]	18[e]	45.2[e]	......	
Chilton	74	23	46.3	0.29	
Cranden	70	22	43.4	0.69	
Delavan	81[e]	22[e]	47.3[e]	......	
Downing	77	12	43.8	1.10	
Eau Claire	76	17	47.0	0.77	
Florence	71	18	42.0	1.14	T.
Fond du Lac	75	23	46.6	0.69	
Grand Rapids	74	18	47.2	1.03	
Grand River Locks	......	......	......	0.93	
Grantsburg	75	15	44.6	0.40	
Hancock	73	18	45.8	0.75	
Hayward	70	10	42.3	0.47	
Herbster	71	21	40.0	0.46	T.
Hillsboro	78	16	44.9	0.85	T.

TABLE II.—*Climatological record of cooperative observers*—Continued. *Late reports for September, 1907.*

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
	°	°	°	*Ins.*	*Ins.*
Wisconsin—Cont'd.					
Koepenick	70	15	42.0	0.90	0.1
Lake Mills	76	23	47.0	1.57	
Lancaster	78	18	45.6	0.54	T.
Manitowoc	75	29	47.7	0.40	
Mauston	76	19	46.9	0.37	
Meadow Valley	78	14	45.8	0.49	
Medford	73	18	44.6	0.90	
Menasha	.....	.....	.....	0.23	
Merrill	72	18	44.6	0.88	T.
Minocqua	68	21	43.0	0.73	T.
Mount Horeb	78	18	46.6	0.90	T.
New London	77	19	46.5	0.27	
New Richmond	77	18	45.6	1.12	
Oconto	75	19	46.5	0.41	
Osceola	80	14	44.4	1.45	T.
Oshkosh	76	21	47.1	0.35	
Pine River	76	19	46.4	0.62	
Portage	75	22	47.1	0.69	
Port Washington	78	26	46.8	1.28	
Prairie du Chien	81	18	49.8	1.37	
Prentice	69	12	42.9	1.17	0.2
Racine	82	30	49.8	1.02	
Sheboygan	78	29	48.8	0.57	
Shullsburg	77	18	47.5	1.17	
Solon Springs	72	12	42.4	0.64	T.
Spooner	71	12	43.1	0.50	T.
Stanley	74	14	44.6	0.57	T.
Stevens Point	76	16	45.8	0.46	
Sturgeon Bay	75	19	46.0	1.20	
Valley Junction	74	15	45.0	0.98	T.
Viroqua	73	21	47.8	1.03	
Watertown	75	22	45.4	1.32	
Waukesha	80	25	47.8	1.17	T.
Waupaca	77	16	47.6	0.59	
Wausau	72	20	45.9	0.50	T.
Weyerhauser	74	13	42.6	1.10	
Whitehall	80	14	49.5	0.72	
Wyoming.					
Barnum	.....	.....	.....	T.	
Basin	76	28	50.6	0.47	
Bedford	73	23	46.3	1.55	
Blue Cap	72	18	41.4	0.17	2.5
Border	75	21	46.5	0.70	
Buffalo	79	28	54.5	0.08	
Camp Colter	.....	.....	.....	0.05	
Chugwater	77	17	48.2	0.10	
Clark	75	33	52.7	0.29	
Daniel	71	16	42.6	0.92	
Dubois	73	10	39.0	0.37	
Elk Mountain	.....	.....	.....	0.39	1.0
Evanston	75	25	46.6	1.22	
Experiment Farm	.....	.....	.....	0.11	
Fayette	71	17	43.3	1.74	
Fontenelle	71	16	44.8	T.	
Fort Laramie	82	23	49.3	0.29	T.
Granite Canyon	74	19	44.2	0.28	
Granite Springs	72	29	47.8	0.30	
Green River	75	19	48.2	0.07	
Griggs	81	21	48.9	0.26	
Hunters	65*	21*	43.4*	.....	
Hyattville	80	28	50.6	.....	
Kinnear	85	22	50.2	T.	
Kirtley	78	19	47.8	0.16	
Laramie	75	20	44.3	0.16	
Leo	71	21	44.7	T.	
Lusk	79	20	48.2	0.00	
Moorcroft	78	20	48.3	0.00	
Moore	76	22	49.0	0.03	
Newcastle	70	20	44.0	T.	
Pathfinder	74	25	48.5	0.24	T.
Phillips	82	22	49.8	0.46	
Pine Bluff	83	20	52.4	0.12	
Rawlins	75^{s}	31^{s}	49.8^{s}	0.17	1.0
Riverton	78	22	48.0	0.04	
Saratoga	72	20	44.2	0.20	
Sheridan	76	21	47.6	0.20	
Wyoming—Cont'd.					
Shoshone	80	33	53.9	0.72	
Wells	64	11	37.6	0.69	3.0
Wheatland	80	29	52.0	0.00	
Worland	82	25	50.6	0.03	
Wyncote	84	23	50.4	0.00	
Yellowstone Pk. (Lake)	62	20	39.8	0.85	3.5
Yellowstone Pk. (Norris)	67	15	40.8	0.31	.....
Yellowstone Pk. (Riv'side)	69	18	42.6	0.50	.....
Yellowstone Pk. (S. River)	69	17	42.4	0.30	T.
Yellowstone Pk. (Soda B.)	70	10	41.4	0.41	
Yellowstone Pk. (T. Sta.)	68	19	41.0	1.38	
Yellowstone Pk. (Up. Ba.)	71	19	43.6	0.04	
Porto Rico.					
Aguirre	97	70	81.8	3.64	
Albonito	89	54	73.4	6.90	
Alto de La Bandera	84	65	73.8	16.57	
Arecibo	90	61	75.2	12.83	
Barros	89	59	73.9	11.35	
Bayamon	95^{1}	68^{1}	81.6^{1}	.....	
Cabo Rojo	.....	.....	.....	3.83	
Caguas	91	62	76.2	5.53	
Canovanas	90	72	79.7	9.32	
Cayey	89	59	74.2	7.16	
Cidra	89	63	75.8	5.13	
Coloso	91	68	79.2	9.95	
Corozal	92	63	80.2	11.20	
Culebra	88	72	79.8	4.64	
Fajardo	91	70	80.4	7.02	
Guanica	94	63	79.0	6.20	
Guayama	.....	.....	.....	4.91	
Humacao	90	69	78.6	9.41	
Ingenio	.....	.....	.....	9.39	
Isabela	93	68	79.8	10.90	
Isolina	89	61	74.5	11.77	
La Carmelita	87	62	74.2	16.23	
Lares	91	60	76.2	19.85	
Las Marias	87^{4}	60	74.6	10.87	
Manati	89	65	77.2	7.72	
Maricao	90	61	75.0	14.38	
Maunabo	93	70	81.4	5.48	
Mayaguez	91	66	78.2	7.92	
Ponce	92	61	80.3	9.37	
Rio Blanco	90	58	77.6	9.90	
Rio Piedras	.....	.....	.....	8.26	
Sabana Grande	.....	.....	.....	11.81	
San German	93	67	79.2	10.65	
San Lorenzo	92	60	76.2	11.66	
San Salvador	87	62	74.7	12.23	
San Sebastin	.....	.....	.....	14.89	
Santa Isabel	93	66	80.2	4.12	
Vieques	90	70	80.2	7.58	
Yauco	91	64	78.6	7.83	
New Brunswick.					
St. John	61	26	43.4	4.55	

Late reports for September, 1907.

Stations.	Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.
Alaska.					
Black Point	.....	.....	.....	3.26	
Chestochina	75	14	44.0	2.07	5.0
Coal Harbor	73	35	49.4	5.84	
Copper Center	60	13	39.8	0.25	
Council	63	20	40.2	0.42	
Deering	67	20	37.8	.....	
Fort Egbert	.....	19	.....	1.45	
Katalla	74	36	50.9	12.34	
Kenai	74	20	47.9	10.00	
Ketchemstock	.....	.....	.....	0.49	2.0
Nome	52	29	41.1	1.41	
Rampart	67	20	39.0	2.52	7.8
Shelton	.....	.....	.....	0.47	
Sunrise	67	26	47.3	4.45	
Tyonok	66	31	48.4	5.76	
Wood Island	71	35	51.7	9.00	
	°	°	°	*Ins.*	*Ins.*
Colorado.					
Nederland	.....	.....	.....	0.81	2.0
Georgia.					
Louisville	.....	.....	.....	7.90	
Iowa.					
Knoxville	90	34	64.7	2.65	
Rock Rapids	86	30	60.4	4.02	
Kentucky.					
Blandville	93	45	70.3	1.59	
Minnesota.					
Zumbrota	80	27	57.6	2.38	
Montana.					
Ridgelawn	85	12	55.6	0.50	
New Jersey.					
Woodbine	90	37	69.2	5.44	
New Mexico.					
Estancia	85	27	60.9	0.00	
Texas.					
Dalhart	110	35	71.9	0.92	
Hereford	93	36	62.6	0.40	
Sonora	100	46	76.8	1.52	
Utah.					
Garrison	87	25	61.0	0.05	
Grantsville	.....	.....	.....	0.24	
Ogden	81	41	62.4	0.02	
Washington.					
Kosmos	97	35	59.7	3.42	
Quiniault	94	38	59.4	5 21	

EXPLANATION OF SIGNS.

* Extremes of temperature from observed readings of dry thermometer.

A numeral following the name of a station indicates the hours of observation from which the mean temperature was obtained, thus:

[1] Mean of 7 a. m. + 2 p. m. + 9 p. m. + 9 p. m. ÷ 4.
[2] Mean of 8 a. m. + 8 p. m. ÷ 2.
[3] Mean of 7 a. m. + 7 p. m. ÷ 2.
[4] Mean of 6 a. m. + 6 p. m. ÷ 2.
[5] Mean of 7 a. m. + 2 p. m. ÷ 2.
[6] Mean of readings at various hours reduced to true daily mean by special tables.

The absence of a numeral indicates that the mean temperature has been obtained from daily readings of the maximum and minimum thermometers.

An italic letter following the name of a station, as "Livingston *a*," "Livingston *b*," indicates that two or more observers, as the case may be, are reporting from the same station. A small roman letter following the name of a station, or in figure columns, indicates the number of days missing from the record; for instance, "n" denotes 14 days missing.

No note is made of breaks in the continuity of temperature records when the same do not exceed two days. All known breaks of whatever duration, in the precipitation record receive appropriate notice.

CORRECTIONS.

April, 1907.

Michigan: Hillsdale, make precipitation 2.96.

May, 1907.

Michigan: Hillsdale, make precipitation 3.98.

June, 1907.

Michigan: Hillsdale, make precipitation 3.14.

July, 1907

Oklahoma: Okeene, make minimum temperature 60.

Oklahoma: Okeene, make mean temperature 81.2.

NOTE: Station closed at Pen Yann, New York, reestablished at Keuka Park, about 4 miles distant. Wyoming Forest Reserve station name changed from Clear Creek Cabin to Hunters.

TABLE III.—*Wind resultants, from observations at 8 a. m. and 8 p. m., daily, during the month of October, 1907.*

Stations.	Component direction from— N.	S.	E.	W.	Resultant. Direction from—	Duration.
	Hours.	Hours.	Hours.	Hours.	°	Hours.
New England.						
Eastport, Me	19	19	5	31	w.	26
Portland, Me	19	20	7	33	s. 88 w.	26
Concord, N. H. †	9	12	3	14	s. 75 w.	11
Burlington, Vt. †	7	17	7	6	s. 6 e.	10
Northfield, Vt	19	29	6	15	s. 42 w.	14
Boston, Mass	20	21	5	32	s. 88 w.	27
Nantucket, Mass	24	18	13	24	n. 61 w.	12
Block Island, R. I	22	25	7	25	n. 81 w.	18
Providence, R. I.	21	18	6	31	n. 83 w.	25
Hartford, Conn.	23	22	4	33	n. 88 w.	29
New Haven, Conn	29	16	7	27	n. 57 w.	24
Middle Atlantic States.						
Albany, N. Y	18	25	5	24	s. 70 w.	20
Binghamton, N. Y. †	8	5	7	17	n. 73 w.	10
New York, N. Y	20	22	4	33	s. 86 w.	29
Harrisburg, Pa	22	18	6	29	n. 80 w.	23
Philadelphia, Pa	26	21	5	27	n. 77 w.	23
Scranton, Pa	24	18	16	22	n. 45 w.	8
Atlantic City, N. J	28	18	1	27	n. 69 w.	28
Cape May, N. J	30	21	6	18	n. 47 w.	16
Baltimore, Md	12	24	7	27	s. 59 w.	23
Washington, D. C	34	16	8	27	n. 47 w.	26
Lynchburg, Va	21	13	15	27	n. 56 w.	14
Mount Weather, Va.	...	...	...	...	...	...
Norfolk, Va	27	22	13	11	n. 67 e.	13
Richmond, Va	24	25	8	18	s. 84 w.	10
Wytheville, Va	14	11	8	42	n. 85 w.	34
South Atlantic States.						
Asheville, N. C	28	16	15	17	n. 9 w.	12
Charlotte, N. C	22	16	23	13	n. 59 e.	12
Hatteras, N. C	33	5	28	14	n. 27 e.	31
Raleigh, N. C	30	14	11	21	n. 32 w.	19
Wilmington, N. C	38	11	17	11	n. 13 e.	28
Charleston, S. C	35	9	22	9	n. 27 e.	29
Columbia, S. C	30	12	17	11	n. 18 e.	19
Augusta, Ga	29	11	20	17	n. 9 e.	18
Savannah, Ga	33	10	22	12	n. 23 e.	25
Jacksonville, Fla	39	6	19	9	n. 17 e.	34
Florida Peninsula.						
Jupiter, Fla	29	11	31	9	n. 51 e.	28
Key West, Fla	37	2	38	2	n. 46 e.	50
Tampa, Fla	39	4	28	5	n. 33 e.	42
Eastern Gulf States.						
Atlanta, Ga	24	14	21	15	n. 31 e.	12
Macon, Ga. †	20	4	5	7	n. 7 w.	16
Thomasville, Ga	29	10	22	10	n. 32 e.	22
Pensacola, Fla. †	21	2	12	3	n. 22 e.	21
Anniston, Ala	22	23	23	8	s. 86 e.	15
Birmingham, Ala	29	8	23	11	n. 30 e.	24
Mobile, Ala	34	16	13	10	n. 9 e.	18
Montgomery, Ala	24	11	26	13	n. 45 e.	18
Meridian, Miss	24	16	25	13	n. 56 e.	14
Vicksburg, Miss	22	16	32	5	n. 78 e.	28
New Orleans, La	27	15	34	5	n. 68 e.	31
Western Gulf States.						
Shreveport, La	22	17	31	10	n. 77 e.	22
Bentonville, Ark. †	10	14	8	7	s. 14 e.	4
Fort Smith, Ark	17	11	31	12	n. 72 e.	20
Little Rock, Ark	25	16	21	16	n. 29 e.	10
Corpus Christi, Tex	24	18	32	3	n. 78 e.	30
Fort Worth, Tex	21	19	25	7	n. 84 e.	18
Galveston, Tex	24	16	31	4	n. 73 e.	28
Palestine, Tex	26	13	33	4	n. 66 e.	32
San Antonio, Tex	29	12	39	1	n. 66 e.	42
Taylor, Tex. †	17	10	6	3	n. 23 e.	8
Ohio Valley and Tennessee.						
Chattanooga, Tenn	28	19	11	20	n. 45 w.	13
Knoxville, Tenn	36	8	18	13	n. 16 e.	19
Memphis, Tenn	25	18	20	12	n. 49 e.	11
Nashville, Tenn	17	12	16	27	n. 66 w.	12
Lexington, Ky. †	4	12	9	10	s. 7 w.	8
Louisville, Ky	21	19	13	23	n. 79 w.	10
Evansville, Ind. †	11	8	8	6	n. 39 e.	4
Indianapolis, Ind	15	26	17	14	s. 15 e.	11
Cincinnati, Ohio	16	18	18	24	s. 72 w.	6
Columbus, Ohio	16	23	16	23	s. 45 w.	10
Pittsburg, Pa	23	14	6	35	n. 73 w.	30
Parkersburg, W. Va	23	21	8	18	n. 79 w.	10
Elkins, W. Va	26	14	10	25	n. 51 w.	19
Lower Lake Region.						
Buffalo, N. Y	22	15	7	29	n. 72 w.	23
Canton, N. Y. †	6	12	2	16	s. 67 w.	15
Oswego, N. Y	16	34	5	16	s. 31 w.	21
Rochester, N. Y	13	22	2	41	s. 77 w.	40
Syracuse, N. Y	10	30	8	22	s. 35 w.	24
Erie, Pa	16	27	8	25	s. 57 w.	20
Cleveland, Ohio	15	32	13	16	s. 10 w.	17
Sandusky, Ohio †	6	12	3	15	s. 63 w.	13
Toledo, Ohio	18	22	6	28	s. 80 w.	22
Detroit, Mich	18	19	7	32	s. 88 w.	25
Upper Lake Region.						
Alpena, Mich	22	16	4	33	n. 78 w.	30
Escanaba, Mich	22	19	6	28	n. 82 w.	22
Grand Haven, Mich	19	21	13	20	s. 74 w.	7
Grand Rapids, Mich	16	22	11	23	s. 63 w.	13
Houghton, Mich. †	9	4	15	8	n. 54 e.	9
Marquette, Mich	21	19	9	29	n. 84 w.	20
Port Huron, Mich	16	23	5	33	s. 76 w.	29
Sault Sainte Marie, Mich	22	15	21	19	n. 16 e.	7
Chicago, Ill	16	23	14	27	s. 62 w.	15
Milwaukee, Wis	15	21	10	30	s. 73 w.	21
Green Bay, Wis	15	29	11	22	s. 38 w.	18
Duluth, Minn	21	14	13	33	n. 71 w.	21
North Dakota.						
Moorhead, Minn	24	25	8	18	s. 84 w.	10
Bismarck, N. Dak	28	13	13	25	n. 39 w.	19
Devils Lake, N. Dak	13	21	16	24	s. 45 w.	11
Williston, N. Dak.	18	19	14	26	s. 85 w.	12
Upper Mississippi Valley.						
Minneapolis, Minn. *	...	...	...	...	...	...
St. Paul, Minn	19	29	18	13	s. 27 e.	11
La Crosse, Wis. †	9	18	3	6	s. 24 w.	10
Madison, Wis.	15	27	10	22	s. 45 w.	17
Charles City, Iowa	19	27	10	17	s. 41 w.	11
Davenport, Iowa	17	18	16	21	s. 79 w.	5
Des Moines, Iowa	16	25	11	21	s. 48 w.	14
Dubuque, Iowa	20	26	9	22	s. 65 w.	14
Keokuk, Iowa	19	25	11	18	s. 56 w.	11
Cairo, Ill	22	23	16	15	s. 45 e.	1
La Salle, Ill. †	10	8	8	11	n. 56 w.	4
Peoria, Ill.	21	27	13	12	s. 9 e.	6
Springfield, Ill	18	26	15	20	s. 32 w.	9
Hannibal, Mo. †	9	10	6	15	s. 84 w.	9
St. Louis, Mo	16	24	18	16	n. 14 e.	8
Missouri Valley.						
Columbia, Mo. *	8	13	10	6	s. 39 e.	6
Kansas City, Mo	20	28	15	12	s. 21 e.	8
Springfield, Mo	13	27	20	13	s. 27 e.	16
Iola, Kans. †	9	13	7	8	s. 14 w.	4
Topeka, Kans. *	9	14	9	6	s. 31 e.	6
Lincoln, Nebr	20	24	16	12	s. 45 e.	6
Omaha, Nebr	17	28	9	20	s. 45 w.	16
Valentine, Nebr	26	17	5	27	n. 68 w.	24
Sioux City, Iowa †	9	13	8	8	s.	4
Pierre, S. Dak	23	14	24	17	n. 38 e.	11
Huron, S. Dak	22	22	17	17	...	...
Yankton, S. Dak. †	9	8	4	13	n. 84 w.	9
Northern Slope.						
Havre, Mont.	19	13	16	28	n. 63 w.	13
Miles City, Mont	17	19	19	21	s. 45 w.	3
Helena, Mont	...	...	...	...	...	...
Kalispell, Mont	8	18	3	39	s. 74 w.	37
Rapid City, S. Dak	...	...	...	...	...	...
Cheyenne, Wyo	27	15	5	27	n. 61 w.	25
Lander, Wyo	23	10	19	24	n. 21 w.	14
Sheridan, Wyo	18	23	25	25	s.	5
Yellowstone Park, Wyo	14	28	3	33	s. 65 w.	33
North Platte, Nebr	24	18	18	18	n.	6
Middle Slope.						
Denver, Colo	27	23	14	8	n. 56 e.	7
Pueblo, Colo	24	12	22	20	n. 9 e.	12
Concordia, Kans	18	26	14	14	s.	8
Dodge, Kans	18	22	26	11	s. 73 e.	14
Wichita, Kans	19	29	17	12	s. 27 e.	11
Oklahoma, Okla	15	33	13	9	s. 13 e.	18
Southern Slope.						
Abilene, Tex	18	29	22	8	s. 52 e.	18
Amarillo, Tex	14	33	10	10	s.	9
Del Rio, Tex †	7	11	19	5	s. 74 e.	15
Roswell, N. Mex.	17	28	10	15	s. 24 w.	12
Southern Plateau.						
El Paso, Tex	17	4	33	10	n. 61 e.	26
Santa Fe, N. Mex	21	19	31	10	n. 85 e.	21
Flagstaff, Ariz	24	15	19	19	n.	9
Phoenix, Ariz	10	14	31	14	s. 77 e.	18
Yuma, Ariz	19	14	19	24	n. 45 w.	7
Independence, Cal	19	27	15	17	s. 14 w.	8
Middle Plateau.						
Reno, Nev	10	15	16	31	s. 72 w.	16
Tonopah, Nev	6	34	28	14	s. 27 e.	31
Winnemucca, Nev	23	16	26	17	n. 52 e.	11
Modena, Utah	8	16	19	32	s. 58 w.	15
Salt Lake City, Utah	14	21	25	20	s. 36 e.	9
Durango, Colo	29	11	8	30	n. 51 w.	28
Grand Junction, Colo	16	14	25	21	n. 63 e.	4
Northern Plateau.						
Baker City, Oreg	14	30	14	17	s. 11 w.	16
Boise, Idaho	15	11	17	18	n. 14 w.	4
Lewiston, Idaho †	0	19	18	2	s. 40 e.	25
Pocatello, Idaho	10	23	28	16	s. 43 e.	18
Spokane, Wash	29	15	16	17	n. 4 w.	14
Walla Walla, Wash	2	41	13	20	s. 10 w.	40
North Pacific Coast Region.						
North Head, Wash	23	21	19	18	n. 27 e.	2
Port Crescent, Wash. *	10	9	11	7	n. 76 w.	4
Seattle, Wash	28	16	19	9	n. 40 w.	16
Tacoma, Wash	31	18	13	10	n. 13 e.	13
Tatoosh Island, Wash	16	15	33	10	n. 88 e.	23
Portland, Oreg	26	18	14	20	n. 37 w.	10
Roseburg, Oreg	26	12	12	25	n. 43 w.	19
Middle Pacific Coast Region.						
Eureka, Cal	26	15	14	20	n. 29 w.	12
Mount Tamalpais, Cal	28	19	12	29	n. 62 w.	19
Red Bluff, Cal	18	28	11	19	s. 39 w.	13
Sacramento, Cal	10	37	18	11	s. 15 e.	28
San Francisco, Cal	8	15	4	42	s. 80 w.	39
San Jose, Cal. †	...	...	...	...	...	...
Southeast Farallon, Cal. *	14	6	1	16	n. 62 w.	17
South Pacific Coast Region.						
Fresno, Cal	17	9	9	40	n. 76 w.	32
Los Angeles, Cal	17	10	19	26	n. 45 w.	10
San Diego, Cal	21	19	11	24	n. 81 w.	22
San Luis Obispo, Cal	28	16	7	11	n. 18 w.	13
West Indies						
San Juan, Porto Rico	3	33	35	4	s. 46 e.	43

* From observations at 8 p. m. only. † From observations at 8 a. m. only.

TABLE IV.—*Accumulated amounts of precipitation for each 5 minutes, for storms in which the rate of fall equaled or exceeded 0.25 in any 5 minutes, or 0.80 in 1 hour, during October, 1907, at all stations furnished with self-registering gages.*

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Abilene, Tex	3			2.58														0.44			
Albany, N. Y	11			0.47									0.31								
Alpena, Mich	6-7			0.60														0.46			
Amarillo, Tex	24			0.54						0.35											
Anniston, Ala	4			0.43														0.26			
Asheville, N. C	27			0.33														0.13			
Atlanta, Ga	7-8			0.90														0.48			
Atlantic City, N. J	27-28			1.76														0.55			
Augusta, Ga	8			0.37									0.37								
Baltimore, Md	8			0.35														0.20			
Bentonville, Ark	3			1.08														0.34			
Binghamton, N. Y	8			0.65														0.31			
Birmingham, Ala	4	7:36 p. m.	8:35 p. m.	0.36	7:39 p. m.	7:49 p. m.	0.01	0.20	0.34												
Bismarck, N. Dak	1			0.43														*			
Block Island, R. I	8	4:45 a. m.	3:25 p. m.	1.11	11:25 a. m.	11:40 a. m.	0.66	0.23	0.31	0.37											
Boise, Idaho	1			0.21														0.16			
Boston, Mass	8	D. N. a. m.	1:45 p. m.	1.14	10:33 a. m.	10:48 a. m.	0.60	0.17	0.31	0.35											
Buffalo, N. Y	7			1.45														0.50			
Cairo, Ill	7	4:34 p. m.	5:30 p. m.	0.66	4:36 p. m.	4:56 p. m.	T.	0.36	0.52	0.59	0.64										
Canton, N. Y	7-8			1.33														0.58			
Charles City, Iowa	1			0.39														0.31			
Charleston, S. C	8	5:04 p. m.	7:40 p. m.	0.79	5:12 p. m.	5:36 p. m.	0.03	0.08	0.21	0.48	0.63	0.67									
Charlotte, N. C	7			0.73														0.30			
Chattanooga, Tenn	7			0.41														0.40			
Cheyenne, Wyo	24-25			0.06									0.02								
Chicago, Ill	3			0.64														*			
Cincinnati, Ohio	3-4	3:25 p. m.	D. N.	1.93	11:25 p. m.	11:41 p. m.	1.52	0.07	0.16	0.39	0.41										
Cleveland, Ohio	3	3:25 p. m.	6:35 p. m.	0.90	3:47 p. m.	4:31 p. m.	0.05	0.05	0.25	0.40	0.48	0.55	0.56	0.58	0.64	0.73					
Columbia, Mo	3			0.89														0.32			
Columbia, S. C	27			0.30														0.23			
Columbus, Ohio	3			0.69														0.38			
Concord, N. H	8			0.62														0.33			
Corpus Christi, Tex	8			0.20									0.18								
Davenport, Iowa	3			0.28									0.25								
Del Rio, Tex	4-5	2:20 p. m.	1:55 p. m.	2.87	2:03 a. m.	2:38 a. m.	1.06	0.15	0.35	0.42	0.47	0.60	0.77	0.82							
Denver, Colo	6-7			0.12														*			
Des Moines, Iowa	2-3			0.36														0.33			
Detroit, Mich	7			0.37														0.33			
Dodge, Kans	3	6:30 a. m.	1:30 p. m.	1.02	8:45 a. m.	9:16 a. m.	0.16	0.16	0.27	0.33	0.38	0.48	0.58	0.61							
Dubuque, Iowa	1			0.30														0.20			
Duluth, Minn	1			0.33														0.09			
Eastport, Me	28-29	10:05 p. m.	7:50 a. m.	2.18	5:18 a. m.	5:38 a. m.	1.16	0.10	0.24	0.44	0.57										
Elkins, W. Va	4			1.01														0.36			
Erie, Pa	7-8			1.03														0.43			
Escanaba, Mich	7			0.38														0.08			
Evansville, Ind	3			0.71														0.25			
Fort Smith, Ark	3	5:20 p. m.	9:36 p. m.	0.88	5:52 p. m.	6:00 p. m.	0.01	0.31	0.37												
Fort Worth, Tex	7	1:20 p. m.	1:32 p. m.	0.47	1:20 p. m.	1:30 p. m.	0.00	0.33	0.47												
Galveston, Tex	29-30	7:10 p. m.	6:40 a. m.	4.18	12:20 a. m.	1:32 a. m.	0.53	0.07	0.45	0.78	1.02	1.06	1.18	1.35	1.78	1.99	2.12	2.33	2.77		
Grand Haven, Mich	3			0.20														0.19			
Grand Rapids, Mich	3			0.68														0.42			
Green Bay, Wis	3			0.41														0.30			
Hannibal, Mo	15	5:15 a. m.	1:20 p. m.	1.86	11:23 a. m.	12:38 p. m.	0.51	0.10	0.27	0.45	0.58	0.64	0.66	0.68	0.68	0.70	0.76	0.90	1.15		
Harrisburg, Pa	28-29			0.62														0.16			
Hartford, Conn	8	2:00 a. m.	12:30 p. m.	1.15	9:34 a. m.	9:45 a. m.	0.64	0.19	0.30												
Hatteras, N. C	27-28			0.40						0.15											
Huron, S. Dak	29			0.27														0.17			
Indianapolis, Ind	3			1.18														0.56			
Iola, Kans	3			2.14														*			
Jacksonville, Fla	2			0.31														0.30			
Jupiter, Fla	10	12:05 p. m.	12:47 p. m.	0.65	12:12 p. m.	12:27 p. m.	0.01	0.29	0.53	0.61											
Do	20	4:51 p. m.	5:50 p. m.	0.80	4:54 p. m.	5:26 p. m.	0.01	0.18	0.35	0.45	0.51	0.62	0.68	0.73							
Kansas City, Mo	3			0.61														0.20			
Keokuk, Iowa	15			0.11														0.07			
Key West, Fla	10-11	10:45 p. m.	5:00 a. m.	0.65	3:13 a. m.	3:30 a. m.	0.16	0.12	0.32	0.42	0.46										
Knoxville, Tenn	4			0.46														0.37			
La Crosse, Wis	1-2			0.28														0.17			
La Salle, Ill	3	D. N. a. m.	5:48 a. m.	0.49	4:41 a. m.	4:51 a. m.	0.08	0.20	0.31												
Lexington, Ky	3-4			1.33														0.52			
Lincoln, Nebr	31			0.72														0.36			
Little Rock, Ark	7	3:40 a. m.	6:50 a. m.	1.26	3:50 a. m.	4:19 a. m.	0.01	0.16	0.30	0.41	0.51	0.71	0.76								
Los Angeles, Cal	16-17			0.39														0.23			
Louisville, Ky	3-4			1.34														0.57			
Lynchburg, Va	27-28			0.50														0.13			
Macon, Ga	9			0.20						0.09											
Madison, Wis	3			0.64														0.55			
Marquette, Mich	3			0.45														0.19			
Memphis, Tenn	4	D. N. a. m.	9:45 a. m.	1.95	2:22 a. m.	3:02 a. m.	0.21	0.09	0.27	0.32	0.49	0.66	0.78	0.87	0.96						
Meridian, Miss	27			0.30														0.18			
Milwaukee, Wis	3			0.16														0.13			
Minneapolis, Minn	1			0.63														0.22			
Mobile, Ala	7	7:25 a. m.	8:45 a. m.	0.54	7:51 a. m.	8:03 a. m.	0.03	0.16	0.38	0.43											
Montgomery, Ala	7			0.61														0.52			
Nantucket, Mass	8			0.82														0.36			
Nashville, Tenn	7	8:35 p. m.	11:45 p. m.	0.48	8:38 p. m.	8:51 p. m.	0.01	0.17	0.26	0.38											
New Haven, Conn	8	2:10 a. m.	12:20 p. m.	1.25	9:36 a. m.	9:51 a. m.	0.55	0.17	0.32	0.39											
New Orleans, La	6	10:58 a. m.	11:48 a. m.	0.43	11:23 a. m.	11:29 a. m.	0.10	0.29	0.32												
New York, N. Y	29			0.71														0.48			
Norfolk, Va	27-28			0.93														0.18			
Northfield, Vt	8			1.03														0.30			
North Head, Wash	28-29			0.38									0.10								
Oklahoma, Okla	3			1.48														0.40			
Omaha, Nebr	1	7:40 a. m.	8:55 a. m.	0.46	8:10 a. m.	8:30 a. m.	T.	0.17	0.29	0.37	0.44										
Palestine, Tex	26	5:50 a. m.	8:45 a. m.	1.56	6:16 a. m.	7:20 a. m.	0.05	0.13	0.19	0.26	0.37	0.52	0.64	0.72	0.82	0.98	1.04	1.25	1.47		
Parkersburg, W. Va	3-4			0.75														0.36			
Pensacola, Fla	7			0.49									0.23								
Peoria, Ill	15			0.06						0.03											
Philadelphia, Pa	8			0.82														0.46			
Pittsburg, Pa	3-4			0.59														0.33			
Portland, Me	4			0.86														0.33			
Portland, Oreg	1			0.45														0.15			

TABLE IV.—*Accumulated amounts of precipitation for each 5 minutes, etc.*—Continued.

Stations.	Date.	Total duration. From—	Total duration. To—	Total amount of precipitation.	Excessive rate. Began—	Excessive rate. Ended—	Amount before excessive began.	5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Pueblo, Colo	24–25			1.36														0.33			
Raleigh, N. C	8			0.06				0.05													
Richmond, Va	27–28			1.98														0.65			
Rochester, N. Y.	3			0.61														0.33			
Sacramento, Cal	27			0.75														0.29			
St. Louis, Mo	3	8:05 a. m.	9:15 a. m.	0.68	8:08 a. m.	8:33 a. m.	0.01	0.19	0.24	0.29	0.51	0.66									
St. Paul, Minn	1			0.56														0.10			
Salt Lake City, Utah	1–2			0.52														0.20			
San Antonio, Tex	29	10:32 a. m.	3:40 p. m.	1.18	12:56 p. m.	1:10 p. m.	0.04	0.23	0.47	0.54											
San Diego, Cal	22–23			0.81									0.24								
Sandusky, Ohio	7	5:05 p. m.	7:55 p. m.	1.27	5:12 p. m.	6:10 p. m.	0.02	0.19	0.33	0.49	0.59	0.65	0.71	0.81	0.87	0.93	0.96	1.07			
San Francisco, Cal	25–26			0.99														0.15			
Savannah, Ga	8–9			0.45														0.22			
Scranton, Pa	7–8			0.92														0.50			
Seattle, Wash	28–29			0.28									0.08								
Shreveport, La	4–5	6:30 p. m.	8:50 a. m.	1.95	8:22 p. m.	8:30 p. m.	0.11	0.32	0.50												
Spokane, Wash	29–30			0.24														0.09			
Springfield, Ill	15			0.56														0.27			
Springfield, Mo	7	11:10 a. m.	11:55 a. m.	0.48	11:21 a. m.	11:40 a. m.	0.02	0.17	0.26	0.39	0.44										
Syracuse, N. Y	8			0.76														0.22			
Tampa, Fla	8	1:35 p. m.	2:25 p. m.	0.58	1:38 p. m.	1:48 p. m.	0.01	0.26	0.37												
Taylor, Tex	19			1.74														0.61			
Thomasville, Ga	27			0.12						0.05											
Toledo, Ohio	7	2:32 p. m.	4:50 p. m.	1.16	2:53 p. m.	3:38 p. m.	0.02	0.12	0.20	0.23	0.24	0.30	0.42	0.83	0.90	1.00*					
Topeka, Kans	2–3			1.09														0.45			
Valentine, Nebr	1			0.30														0.16			
Vicksburg, Miss	26	6:30 p. m.	D. N. p. m.	1.01	8:03 p. m.	8:27 p. m.	0.08	0.06	0.11	0.28	0.55	0.62									
Washington, D. C	7–8			0.64														0.46			
Wichita, Kans	3	1:03 a. m.	3:00 p. m.	1.65	1:18 a. m.	1:36 a. m.	0.03	0.06	0.26	0.57	0.61										
Wytheville, Va	27–28			0.56														0.23			
Yankton, S. Dak	29			0.04						0.01											
San Juan, P. R.	22	12:28 p. m.	1:48 p. m.	0.98	12:48 p. m.	1:20 p. m.	0.02	0.31	0.69	0.75	0.80	0.85	0.91	0.94							

* Self-register not working. † No precipitation during the month.

TABLE V.—*Data furnished by the Canadian Meteorological Service, October, 1907.*

Stations.	Pressure, in inches. Actual, reduced to mean of 24 hours.	Pressure. Sea level, reduced to mean of 24 hours.	Pressure. Departure from normal.	Temperature. Mean.	Temperature. Departure from normal.	Temperature. Mean maximum.	Temperature. Mean minimum.	Precipitation. Total.	Precipitation. Departure from normal.	Precipitation. Total snowfall.
	Ins.	Ins.	Ins.	°	°	°	°	Ins.	Ins.	Ins.
St. Johns, N. F	29.72	29.86	–.05	45.3	– 0.1	51.6	38.9	12.01	+6.66	
Sydney, C. B. I	29.91	29.95	–.01	45.9	– 0.6	52.9	38.9	7.14	+2.45	
Halifax, N. S	29.86	29.97	–.03	45.6	– 1.6	53.0	38.2	5.34	–0.21	3.0
Grand Manan, N. B	29.90	29.95	–.05	46.7	– 0.2	53.0	40.4	5.09	+0.38	5.3
Yarmouth, N. S	29.92	29.99	–.03	45.6	– 2.0	52.4	38.9	4.78	+0.08	0.2
Charlottetown, P. E. I	29.89	29.93	–.03	45.5	– 1.0	51.3	39.7	4.54	–0.36	3.4
Chatham, N. B	29.91	29.93	–.03	43.8	+ 0.8	53.2	34.3	3.78	–0.08	0.2
Father Point, Que	29.89	29.91	–.04	39.3	– 0.5	45.8	32.8	5.79	+2.89	3.0
Quebec, Que	29.64	29.97	–.03	40.0	– 2.2	46.8	33.2	5.32	+2.17	2.3
Montreal, Que	29.79	30.00	–.01	43.4	– 1.4	50.0	36.8	3.52	+0.39	T.
Rockliffe, Ont	29.42	30.04	+.03	39.1	– 3.7	48.2	30.1	1.68	–0.75	2.6
Ottawa, Ont	29.74	30.08	+.07	42.8	– 1.0	50.3	35.4	3.05	+0.50	4.3
Kingston, Ont	29.74	30.06	+.03	44.8	– 2.2	53.3	36.4	2.56	–0.17	
Toronto, Ont	29.68	30.06	+.02	45.0	– 1.6	53.6	36.3	1.97	–0.39	
White River, Ont										
Port Stanley, Ont	29.45	30.10	+.05	44.9	– 2.9	53.9	36.0	3.43	+0.45	
Saugeen, Ont										

Stations.	Pressure, in inches. Actual, reduced to mean of 24 hours.	Pressure. Sea level, reduced to mean of 24 hours.	Pressure. Departure from normal.	Temperature. Mean.	Temperature. Departure from normal.	Temperature. Mean maximum.	Temperature. Mean minimum.	Precipitation. Total.	Precipitation. Departure from normal.	Precipitation. Total snowfall.
	Ins.	Ins.	Ins.	°	°	°	°	Ins.	Ins.	Ins.
Parry Sound, Ont	29.34	30.05	+.04	42.2	– 1.7	51.7	32.7	2.58	–1.34	T.
Port Arthur, Ont	29.33	30.04	+.06	39.4	– 0.5	48.6	30.1	2.47	–0.09	1.4
Winnipeg, Man	29.20	30.05	+.07	41.4	– 2.3	53.0	29.8	0.40	–1.30	T.
Minnedosa, Man	28.19	30.04	+.07	41.1	– 3.3	52.9	29.2	0.36	–0.84	0.1
Regina, Sask	28.01			42.6	+ 3.2	58.3	27.0	0.08	–1.02	
Medicine Hat, Alberta	27.68	29.96	–.01	51.8	+ 7.0	66.1	37.6	0.00	–0.58	
Swift Current, Sask	27.46	30.05	+.08	46.3	+ 4.2	61.6	31.0	0.04	–0.84	
Calgary, Alberta	26.45	29.99	+.04	48.0	+ 7.9	62.3	33.7	0.15	–0.33	
Banff, Alberta	25.43	30.03	+.08	44.6	+ 5.3	56.7	32.5	0.96	–0.06	
Edmonton, Alberta	27.65	29.95	+.02	47.4	+ 6.3	60.3	34.6	0.19	–0.51	
Prince Albert, Sask	28.36	29.93	–.04	42.1	+ 5.0	54.9	29.2	0.56	–0.27	
Battleford, Sask	28.22	29.97	.00	42.6	+ 3.0	59.6	25.6	0.04	–0.41	
Kamloops, B. C										
Victoria, B. C										
Barkerville, B. C										
Hamilton, Bermuda	29.89	30.05	+.02	73.0	0.0	78.0	68.0	7.02	+0.31	
Dawson, Yukon										

TABLE VI.—*Heights of rivers referred to zeros of gages, October, 1907.*

Stations.	Distance to mouth of river.	Flood stage on gage.	Highest water.		Lowest water.		Mean stage.	Monthly range.
			Height.	Date.	Height.	Date.		
	Miles.	*Feet.*	*Feet.*		*Feet.*		*Feet.*	*Feet.*
Yellowstone River.								
Billings, Mont.	330	8	2.3	1,2	1.5	29-31	1.8	0.8
James River.								
Huron, S. Dak.	139	9	−0.1	1,14	−0.3	27	−0.2	0.2
Republican River.								
Clay Center, Kans.	42	18	11.0	4	5.0	13,14	5.8	6.0
Smoky Hill-Kansas River.								
Abilene, Kans.	254	22	6.8	5	0.0	17,18,24-31	1.1	6.8
Manhattan, Kans	160	18	7.7	5	2.5	1	3.5	5.2
Topeka, Kans.	87	21	9.5	6	5.2	1	6.1	4.3
Missouri River.								
Townsend, Mont.	2,504	11	4.7	7,10-12	4.5	1,23-31	4.6	0.2
Fort Benton, Mont.	2,285	12	2.4	25	0.7	31	1.8	1.7
Wolfpoint, Mont.	1,952	17	−0.5	1,16-19	−0.7	5-14,22-28	−0.6	0.2
Bismarck, N. Dak.	1,309	14	3.0	1	1.9	18,19	2.2	1.1
Pierre, S. Dak.	1,114	14	1.9	7,8	1.2	31	1.3	0.7
Sioux City, Iowa	784	17	6.9	10,11	6.5	14-22,26-31	6.6	0.4
Blair, Nebr.	705	15	6.7	1,2,4	5.8	30	6.2	0.9
Omaha, Nebr.	669	18	8.7	1-3,5,12	7.7	24	8.2	1.0
St. Joseph, Mo	481	10	2.8	5,6	1.1	20-29	1.6	1.7
Kansas City, Mo.	388	21	9.5	6,8	7.1	23,24,27-29	7.9	2.4
Glasgow, Mo.	231	18	6.8	10	4.9	25,29	5.7	1.9
Boonville, Mo.	199	20	9.7	10	7.8	31	8.5	1.9
Hermann, Mo.	103	24	7.6	11	5.9	30,31	6.6	1.7
Minnesota River.								
Mankato, Minn	127	18	3.4	6,7	2.0	25-31	2.5	1.4
St. Croix River.								
Stillwater, Minn.	23	11	7.5	1	3.6	30,31	4.9	3.9
Illinois River.								
La Salle, Ill.	197	18	19.2	1	13.7	31	16.0	5.5
Peoria, Ill.	135	14	14.1	8	10.7	31	12.6	3.4
Conemaugh River.								
Johnstown, Pa.*	64	7	1.8	5,29	0.8	24-27	1.2	1.0
Allegheny River.								
Warren, Pa.	177	14	2.3	29,30	0.1	1-4	1.3	2.2
Parker, Pa.	73	20	4.0	6	0.5	1	2.1	3.5
Freeport, Pa.	29	20	7.4	6	2.6	27	4.3	4.8
Youghiogheny River.								
Confluence, Pa.	59	10	2.0	29	0.2	24-27	0.7	1.8
West Newton, Pa.	15	23	2.8	9,29	0.2	26,27	1.2	2.6
Monongahela River.								
Fairmont, W. Va.	119	25	17.4	6	14.4	27	15.3	3.0
Greensboro, Pa.	81	18	10.6	9	6.8	26,27	8.1	3.8
Lock No. 4, Pa.	40	28	13.3	30	6.8	4,5	8.8	6.5
Muskingum River.								
Zanesville, Ohio	70	25	9.0	7,31	7.9	23-27	8.3	1.1
Little Kanawha River.								
Creston, W. Va.	38	20	5.4	6	2.4	3,19-27	3.0	3.0
New-Great Kanawha River.								
Hinton, W. Va.	153	14	3.0	10	1.3	26,27	1.7	1.7
Charleston, W. Va.	58	30	8.5	9	4.2	15	6.1	4.3
Scioto River.								
Columbus, Ohio	110	17	3.0	4	1.9	29	2.2	1.1
Licking River.								
Falmouth, Ky.	30	25	3.0	4	0.5	25-27, 30,31	1.1	2.5
Kentucky River.								
Beattyville, Ky	254	30	4.3	9	0.1	7,18-20, 23-26	0.5	4.2
Frankfort, Ky.	65	31	8.2	10	4.8	31	5.8	3.4
Wabash River.								
Mount Carmel, Ill.	75	15	4.9	7,8	1.7	3,4	2.7	3.2
Cumberland River.								
Burnside, Ky.	518	50	5.5	9	0.0	31	1.1	5.5
Celina, Tenn.	383	45	6.6	11	1.2	26,27, 29-31	2.4	5.4
Carthage, Tenn.	308	40	3.9	12	0.9	31	1.9	3.0
Nashville, Tenn	193	40	9.5	13	7.0	26	8.0	2.5
Clarksville, Tenn.	126	43	6.3	14	1.5	28	3.7	4.8
Clinch River.								
Speers Ferry, Va.	156	20	0.5	9	−0.4	26	0.0	0.9
Clinton, Tenn	52	25	5.0	10	2.9	27,28	3.7	2.1
South Fork Holston River.								
Bluff City, Tenn.	35	12	2.0	5	0.9	26,27	1.2	1.1
Holston River.								
Rogersville, Tenn.	103	14	2.9	6	1.6	26,27	2.0	1.3
French Broad River.								
Asheville, N. C.	144	4	−0.2	1	−0.7	23-27,29-31	−0.5	0.5
Dandridge, Tenn.	46	12	2.1	5	0.5	21-27	0.8	1.6
Tennessee River.								
Knoxville, Tenn.	635	12	2.4	7	0.7	24-28	1.2	1.7
Loudon, Tenn	590	25	2.6	1	1.0	21-27	1.5	1.6
Kingston, Tenn.	556	25	2.8	1	1.4	20-24	1.8	1.4
Chattanooga, Tenn.	452	33	5.6	1	2.0	21-29	2.9	3.6
Bridgeport, Ala	402	24	3.5	1	0.6	27,28	1.6	2.9
Guntersville, Ala.	349	31	6.9	1	2.1	29	3.6	4.8
Florence, Ala.	255	16	4.0	1	0.3	28-31	1.3	3.7
Riverton, Ala.	225	26	7.0	1	1.6	29	3.2	5.4
Johnsonville, Tenn.	95	21	8.6	1	1.5	29,31	3.3	7.1
Ohio River.								
Pittsburg, Pa.	966	22	7.0	6	3.1	14	5.8	3.9
Dam No. 2, Pa.	956	25	7.5	7,11,30	2.1	27	4.4	5.4
Beaver Dam, Pa.	925	27	10.3	11	4.3	27,28	6.7	6.0
Wheeling, W. Va.	875	36	9.8	8,12	4.0	23-28	6.2	5.8
Parkersburg, W. Va.	785	36	10.2	9	4.5	28	6.9	5.7
Point Pleasant, W. Va.	703	39	12.7	10	3.1	27,28	5.8	9.6
Huntington, W. Va	660	50	16.9	10	6.0	28,29	9.2	10.9
Catlettsburg, Ky.	651	50	16.9	10	4.6	29	8.0	12.3
Portsmouth, Ohio	612	50	16.8	11	5.3	29	8.7	11.5
Maysville, Ky.	559	50	16.1	12	5.5	30	8.8	10.6
Cincinnati, Ohio	499	50	17.2	12	7.0	31	10.6	10.2
Madison, Ind	413	46	14.7	13	6.4	31	9.6	8.3
Louisville, Ky.	367	28	7.9	13	3.5	31	5.3	4.4
Evansville, Ind	184	35	11.8	16	5.5	31	8.2	6.3
Mount Vernon, Ind.	148	35	11.0	17	4.3	31	7.5	6.7
Ohio River—Cont'd.								
Paducah, Ky.	47	40	8.6	1	3.8	31	6.8	4.8
Cairo, Ill.	1	45	16.1	12-14,18	9.9	31	14.4	6.2
Neosho River.								
Iola, Kans.	262	10	1.3	6	−1.3	1	−0.3	2.6
Oswego, Kans.	184	20	1.2	9	0.0	1,2	0.4	1.2
Fort Gibson, Ind. T	3	22	10.0	7,8	8.7	1-5,18-31	8.9	1.3
Canadian River.								
Calvin, Ind. T.	99	10	7.0	5	2.4	24,25	3.0	4.6
Black River.								
Blackrock, Ark.	67	12	3.0	9	2.3	2-4,22-31	2.4	0.7
White River.								
Calicorock, Ark	272	18	−0.1	8-10	−0.6	22,23,28-31	−0.4	0.5
Batesville, Ark.	217	18	2.0	4	1.5	24-31	1.7	0.5
Clarendon, Ark.	75	30	8.1	9	7.3	29-31	7.7	0.8
Arkansas River.								
Wichita, Kans.	832	10	−0.7	5	−1.6	1,2	−1.2	0.9
Tulsa, Ind. T.	551	16	3.6	9	2.3	1,2	2.9	1.3
Webbers Falls, Ind. T.	465	23	4.4	11	2.4	4,5	3.2	2.0
Fort Smith, Ark.	403	22	4.3	9	1.2	7	2.3	3.1
Dardanelle, Ark.	256	21	3.5	11	1.4	2,3,26-28,30	5.2	2.1
Little Rock, Ark.	176	23	4.4	13	2.2	29	2.6	2.2
Pine Bluff, Ark.	121	25	6.8	14	4.5	31	5.3	2.3
Yazoo River.								
Greenwood, Miss	175	38	3.9	11	1.7	29-31	2.4	2.2
Yazoo City, Miss.	80	25	0.4	15,16	−1.6	1-7	−0.8	2.0
Ouachita River.								
Camden, Ark.	304	39	8.3	12	3.3	5-7	4.7	5.0
Monroe, La	122	40	4.9	18,19	2.7	31	3.5	2.2
Red River								
Fulton, Ark.	515	28	21.4	9	6.6	5	11.0	14.8
Shreveport, La.	327	29	11.6	11	−1.8	3	2.7	13.4
Alexandria, La.	118	33	12.5	14	1.6	2-7	5.3	10.9
Mississippi River.								
Fort Ripley, Minn.	2,082	10	5.7	2	5.0	14,28	5.3	0.7
St. Paul, Minn.	1,954	14	5.1	5	3.8	30-31	4.3	1.3
Red Wing, Minn.	1,914	14	5.5	1	2.2	29-31	3.3	3.3
Reeds Landing, Minn	1,884	12	5.2	1	2.1	30,31	3.4	3.1
La Crosse, Wis.	1,819	12	7.1	1	3.3	31	4.6	3.8
Prairie du Chien, Wis.	1,759	18	8.2	1,2	3.7	28-31	5.3	4.5
Dubuque, Iowa.	1,699	15	8.9	4	3.9	31	6.0	5.0
Leclaire, Iowa.	1,609	10	6.1	5	2.4	30,31	4.1	3.7
Davenport, Iowa	1,593	15	8.6	5,6	3.6	31	5.8	5.0
Muscatine, Iowa	1,562	16	9.9	6	4.4	31	6.8	5.5
Galland, Iowa.	1,472	8	4.8	8	2.0	28-31	3.3	2.8
Keokuk, Iowa.	1,463	15	8.5	7,8	3.2	29-31	5.7	5.3
Warsaw, Ill.	1,458	18	11.4	8	6.2	31	8.6	5.2
Hannibal, Mo	1,402	13	9.8	9	4.0	30,31	6.5	5.8
Grafton, Ill	1,306	23	11.1	12	7.0	31	9.1	4.1
St. Louis, Mo	1,264	30	13.1	11,12	7.1	31	10.2	6.0
Chester, Ill	1,189	30	10.5	13	6.0	31	8.4	4.5
New Madrid, Mo.	1,003	34	13.2	13,14	8.4	31	11.9	4.8
Luxora, Ark	905	33	6.1	16-19	3.3	31	5.3	2.8
Memphis, Tenn	843	33	11.1	15,16	7.3	31	10.1	3.8
Helena, Ark.	767	42	14.3	15-17	10.2	31	13.2	4.1
Arkansas City, Ark.	635	42	16.1	17,18	12.0	31	14.9	4.1
Greenville, Miss.	595	42	12.6	18	9.4	31	11.7	3.2
Vicksburg, Miss.	474	45	12.8	19	10.0	31	11.9	2.8
Natchez, Miss.	373	46	14.4	20-22	12.2	5	13.9	2.2
Baton Rouge, La.	240	35	8.7	20-24	6.7	5	7.8	2.0
Donaldsonville, La	188	28	6.5	22	5.0	5-8	5.7	1.5
New Orleans, La.	108	16	5.0	17,18,24-29	4.4	6-9	4.8	0.6
Atchafalaya River.								
Simmesport, La.	127	33	10.8	18	6.4	5-7	8.5	4.4
Melville, La.	103	31	15.0	17-19	10.5	7	12.8	4.5
Hudson River.								
Troy, N. Y	154	14	9.4	31	3.3	27	4.9	6.1
Albany, N. Y.	147	12	8.5	30	2.4	19	4.2	6.1
Delaware River.								
Hancock (E. Branch), N. Y.	287	12	7.4	29	3.1	3	3.9	4.3
Hancock (W. Branch), N. Y.	287	10	6.3	29	3.1	27	4.2	3.2
Port Jervis, N. Y.	215	14	4.8	29,30	0.6	27	1.7	4.2
Phillipsburg, N. J.	146	26	8.5	30	1.7	27	3.3	6.8
Trenton, N. J.	92	18	4.2	29	1.8	26,27	2.7	2.4
North Branch Susquehanna.								
Binghamton, N. Y.	183	16	6.9	9	2.5	26,27	3.8	4.4
Towanda, Pa	139	16	5.3	10	1.2	1,2	2.6	4.1
Wilkes-Barre, Pa.	60	17	9.1	11	3.8	1,2	5.8	5.3
West Branch Susquehanna.								
Williamsport, Pa.	39	20	3.2	30	0.9	26,27	1.7	2.3
Susquehanna River.								
Harrisburg, Pa.	69	17	4.0	12	1.8	27	2.5	2.2
Shenandoah River.								
Riverton, Va.	58	22	−0.4	1	−1.6	29-31	−1.1	1.2
Potomac River.								
Cumberland Md.	290	8	3.0	28	1.9	21-27	2.3	1.1
Harpers Ferry, W. Va.	172	18	3.0	2	−0.4	29-31	0.7	3.4
James River.								
Lynchburg, Va.	260	18	2.0	1	0.9	26-31	1.3	1.1
Columbia, Va.	167	18	5.0	1	2.3	31	3.1	2.7
Richmond, Va.	111	10	0.7	1,2,12	−0.3	22	0.2	1.0
Roanoke River.								
Clarksville, Va	196	12	0.1	1	−0.5	14-17,20-24	−0.3	0.6
Weldon, N. C.	129	30	10.1	1-3	9.3	23,24	9.6	0.8
Tar River.								
Greenville, N. C.	21	22	5.0	2	2.8	29,30	3.4	2.2
Cape Fear River.								
Fayetteville, N. C	112	38	6.9	1	0.7	12	1.9	6.2
Pedee River.								
Cheraw, S. C	149	27	4.9	1	1.2	27	1.8	3.7
Smiths Mills, S. C.	51	16	9.9	1	1.0	23,26,31	3.6	8.9
Lynch Creek.								
Effingham, S. C.	35	12	5.3	2,3	2.9	22,23	3.6	2.4

Table VI.—*Heights of rivers referred to zeros of gages*—Continued.

Stations.	Distance to mouth of river.	Flood stage on gage.	Highest water. Height.	Highest water. Date.	Lowest water. Height.	Lowest water. Date.	Mean stage.	Monthly range.
	Miles.	Feet.	Feet.		Feet.		Feet.	Feet.
Black River.								
Kingstree, S. C	45	12	6.3	3	0.4	30, 31	3.3	5.9
Catawba-Wateree River.								
Mount Holly, N. C	143	15	2.0	1, 2, 28-30	1.8	11-27	1.9	0.2
Catawba, S. C	107	11	2.5	29	1.2	14, 27	1.7	1.3
Camden, S. C	37	14	9.6	1	2.5	21	4.8	7.1
Congaree River.								
Columbia, S. C	52	15	2.5	29	0.0	13, 20, 27	0.7	2.5
Savannah River.								
Calhoun Falls, S. C	347	15	3.9	1	2.3	24, 26, 27	2.9	1.6
Augusta, Ga	268	32	11.6	1	4.7	23	5.9	6.9
Oconee River.								
Dublin, Ga	79	30	7.0	2	− 1.0	31	0.6	8.0
Ocmulgee River.								
Macon, Ga	203	18	3.6	1	0.4	29	1.1	3.2
Flint River.								
Montezuma, Ga	152	20	5.3	1	0.3	31	1.9	5.0
Albany, Ga	90	20	11.0	1	0.5	29-31	2.3	10.5
Bainbridge, Ga	29	22	13.4	3	3.1	28-31	5.8	10.3
Chattahoochee River.								
West Point, Ga	239	20	3.1	1	1.6	27	2.0	1.5
Eufaula, Ala	90	40	3.4	1	0.5	20	1.5	2.9
Alaga, Ala	30	25	8.2	1	1.9	21, 24-27, 30, 31	3.1	6.3
Coosa River.								
Rome, Ga	266	30	2.0	1, 2, 4-6	0.6	25, 29	1.3	1.4
Gadsden, Ala	162	22	5.5	2	0.6	27, 28	1.5	4.9
Lock No. 4, Ala	113	17	4.6	2	0.5	22-31	1.2	4.1
Wetumpka, Ala	12	45	6.8	4	1.5	19	2.9	5.3
Alabama River.								
Montgomery, Ala	323	35	4.5	4	0.7	24-26	1.9	3.8
Selma, Ala	246	35	4.5	1	0.0	25-31	1.3	4.5
Black Warrior River.								
Tuscaloosa, Ala	90	43	9.4	1	4.9	25-30	5.9	4.5
Tombigbee River.								
Columbus, Miss	316	33	− 2.0	13	− 3.1	5-9, 19-31	−2.9	1.1
Demopolis, Ala	168	35	4.1	1	− 1.9	26, 27, 30, 31	−0.1	6.0
Pascagoula River.								
Merrill, Miss	78	20*	4.8	1	1.3	27, 31	2.6	3.5
Pearl River.								
Columbia, Miss	110	14	4.9	7, 8	3.6	18-21, 25-28	3.8	1.3
Sabine River.								
Logansport, La	315	25	2.2	9	0.2	1	0.9	2.0
Neches River.								
Beaumont, Tex	18	10	2.2	4	0.8	14	1.5	1.4
Trinity River.								
Dallas, Tex	320	25	24.5	7	2.8	1-4	9.3	21.7
Long Lake, Tex	211	35	20.0	31	2.0	4	8.7	18.0
Liberty, Tex	20	25	16.1	31	4.5	9	8.3	11.6
Brazos River.								
Waco, Tex	285	22	9.2	6	3.0	1-3	5.2	6.2
Hempstead, Tex	140	40	10.8	12	− 1.7	1-4	3.4	12.5
Booth, Tex	61	39	4.7	17, 24	3.4	29-31	3.8	1.3
Colorado River.								
Austin, Tex	214	18	8.3	9	1.6	2	3.1	6.7
Columbus, Tex	98	24	20.0	30	5.3	1, 2	10.2	14.7
Rio Grande.								
San Marcial, N. Mex	1,233	11	10.7	24	9.0	31	9.4	1.7
El Paso, Tex	1,030	14	10.5	28, 29	8.8	11, 12	9.4	1.7
Red River of the North.								
Moorhead, Minn	284	26	8.4	5-9, 12	7.9	31	8.0	0.5
Snake River.								
Lewiston, Idaho	144	24	2.4	31	1.5	1	1.9	0.9
Columbia River.								
Wenatchee, Wash	473	40	11.6	1	7.6	31	9.6	4.0
Umatilla, Oreg	270	25	5.3	1	3.2	31	4.3	2.1
The Dalles, Oreg	166	40	7.4	1, 2	3.9	31	5.7	3.5
Willamette River.								
Albany, Oreg	118	20	1.1	4	0.6	23-29	0.8	0.5
Portland, Oreg	12	15	4.5	8	1.4	30	3.0	3.1
Sacramento River.								
Red Bluff, Cal	265	23	1.8	31	0.9	1-12	1.1	0.9
Sacramento, Cal	64	25	8.0	30, 31	7.3	12, 13	7.5	0.7

* 3 days missing.

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Honolulu, T. H., latitude 21° 19′ north, longitude 157° 30′ west; barometer above sea, 38 feet; gravity correction, —0.057 inch, applied. October, 1907.

Day.	Pressure.*		Air temperature.				Moisture.				Wind.				Precipitation.		Clouds.					
							8 a. m.		8 p. m.		8 a. m.		8 p. m.				8 a. m.			8 p. m.		
	8 a. m.	8 p. m.	8 a. m.	8 p. m.	Maximum.	Minimum.	Wet.	Relative humidity.	Wet.	Relative humidity.	Direction.	Velocity.	Direction.	Velocity.	8 a. m.	8 p. m.	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.
1	30.06	30.00	79.0	75.2	82	73	68.3	58	98.0	69	e.	5	e.	7	0.00	0.00	1	Cu.	e.	0	0	0
2	30.00	29.95	79.2	75.0	84	71	69.5	61	70.0	78	ne.	4	ne.	3	0.00	0.00	1	Cu.	e.	1	A.-s.	0
3	29.94	29.93	78.0	75.0	83	71	70.5	69	69.0	74	ne.	3	w.	3	0.00	0.00	4	Cu.	e.	0	0	0
4	29.93	29.96	79.0	78.0	84	70	70.2	65	71.0	71	se.	6	e.	4	0.00	0.00	Few	Cu.	e.	4	S.	sw.
5	30.02	30.01	78.5	76.0	83	74	69.0	62	68.0	66	ne.	8	ne.	9	0.00	0.00	8 1	Ci.-s. Cu.	s. e.	0	0	0
6	30.04	30.01	77.2	76.5	81	75	67.7	61	69.0	68	ne.	4	ne.	20	0.00	0.00	7	Cu.	e.	4	S.	ne.
7	29.99	29.95	78.7	76.5	83	75	68.0	55	69.0	68	e.	8	e.	14	0.01	0.00	4	Cu.	e.	1	Cu.	e.
8	29.99	29.95	80.0	75.5	83	74	69.0	57	69.0	72	ne.	5	ne.	14	0.00	0.00	1	Cu.	e.	0	0	0
9	29.98	29.96	79.0	75.7	84	72	69.5	62	69.2	72	ne.	1	e.	5	0.00	0.00	Few	Cu.	e.	0	0	0
10	29.98	29.94	74.0	73.0	79	70	71.0	86	69.0	82	e.	1	ne.	4	0.05	0.25	9	N.	e.	Few	Cu.	ne.
11	29.94	29.92	78.0	74.0	80	70	71.0	71	70.0	82	e.	2	ne.	3	0.00	0.00	Few	Cu.	0	0	0	0
12	29.92	29.90	76.8	75.5	84	72	72.0	79	71.5	82	w.	4	ne.	3	0.00	0.00	Few	Cu.	e.	0	0	0
13	29.91	29.88	79.3	76.0	82	73	72.0	70	72.0	82	se.	3	n.	2	0.00	0.00	7	A.-cu.	w.	1 6	Ci.-cu. A.-s.	n. n.
14	29.87	29.86	81.5	76.0	83	74	73.0	67	73.0	87	e.	1	ne.	5	0.00	0.00	4	Ci.-cu.	w.	9	Cu.	ne.
15	29.90	29.90	79.0	77.0	84	72	72.0	71	71.0	74	e.	1	ne.	10	0.00	0.00	4 1	A.-cu. A.-s.	w. 0	1	A.-s.	nw.
16	29.96	29.95	75.0	75.0	80	72	70.0	78	67.0	66	ne.	6	n.	9	0.03	0.00	8	S.-cu.	ne.	Few	Cu.	n.
17	29.98	29.99	76.0	75.0	80	73	66.2	60	66.0	62	ne.	15	ne.	12	0.00	0.00	1	Cu.	e.	8	Cu.	ne.
18	30.03	30.03	74.5	75.0	79	72	67.0	68	66.0	62	ne.	13	ne.	12	0.00	0.00	1 8	A.-cu. Cu.	0 e.	6	Cu.	ne.
19	30.04	30.02	76.2	76.0	80	74	64.2	51	68.0	66	ne.	13	ne.	4	0.00	0.00	1	Ci.-s.	?	7	Cu.	ne.
20	30.08	30.05	76.8	76.0	81	74	66.0	56	68.0	66	e.	8	e.	12	0.00	0.00	4 3	Ci.-s. Cu.	w. e.	5	Cu.	ne.
21	30.05	30.05	76.0	76.0	81	74	67.2	63	67.0	62	e.	7	e.	8	0.00	0.00	8	S.-cu.	e.	7	Cu.	e.
22	30.04	30.02	76.3	72.0	81	72	67.0	69	69.0	86	ne.	6	e.	6	0.00	0.01	1 7	A.-cu. S.-cu.	0 e.	9	N.	e.
23	30.02	30.02	75.2	75.0	82	72	68.0	69	69.0	74	ne.	6	ne.	6	0.01	T.	4 4	A.-cu. S.-cu.	e. e.	5	Cu.	e.
24	30.01	30.01	77.2	74.0	84	70	68.2	63	69.0	78	e.	9	ne.	8	0.01	0.00	2	Cu.	e.	9	S.	ne.
25	30.03	30.02	74.0	74.5	82	70	70.0	82	68.0	72	n.	3	n.	6	0.14	0.00	7 1	S.-cu. Cu.-n.	e. 0	2 1	S.-cu. Cu.-n.	n. ne.
26	30.04	30.02	78.0	75.0	81	72	68.6	62	68.0	70	ne.	4	ne.	6	0.00	0.02	6	Cu.	ne.	2 1	Cu. Cu.-n.	ne. ne.
27	30.05	30.05	76.0	75.5	80	70	68.0	66	69.0	72	ne.	9	ne.	8	0.05	T.	5	Cu.	e.	9	N.	e.
28	30.08	30.06	75.2	76.0	79	72	67.0	65	68.5	68	ne.	9	ne.	9	0.01	0.00	2	Cu.	ne.	1	S.	ne.
29	30.10	30.07	77.5	75.5	80	74	68.0	62	68.0	68	ne.	5	e.	10	0.00	0.00	5	Cu.	e.	4 4	Cu. S.	ne. ne.
30	30.08	30.05	78.0	75.0	81	72	67.2	57	69.0	74	e.	8	e.	7	0.00	0.00	4 2	Ci. Cu.	0 e.	10	S.	e.
31	30.06	29.94	75.5	73.2	78	71	74.0	93	69.5	83	e.	14	ne.	10	0.35	0.09	1 5	A.-cu. S.-cu.	0 e.	8	N.	ne.
Mean	30.004	29.986	77.2	75.3	81.5	72.3	69.0	66.4	69.0	72.8	ne.	6.2	ne.	7.7	0.66	0.37	7.8	Cu.	e.	4.0	Cu.	ne.

Observations are made at 8 a.m. and 8 p. m., local standard time, which is that of 157° 30′ west, and is 5h and 30m slower than 75th meridian time. *Pressure values are reduced to sea level and standard gravity.

Chart I. Hydrographs for Seven Principal Rivers of the United States, October, 1907.

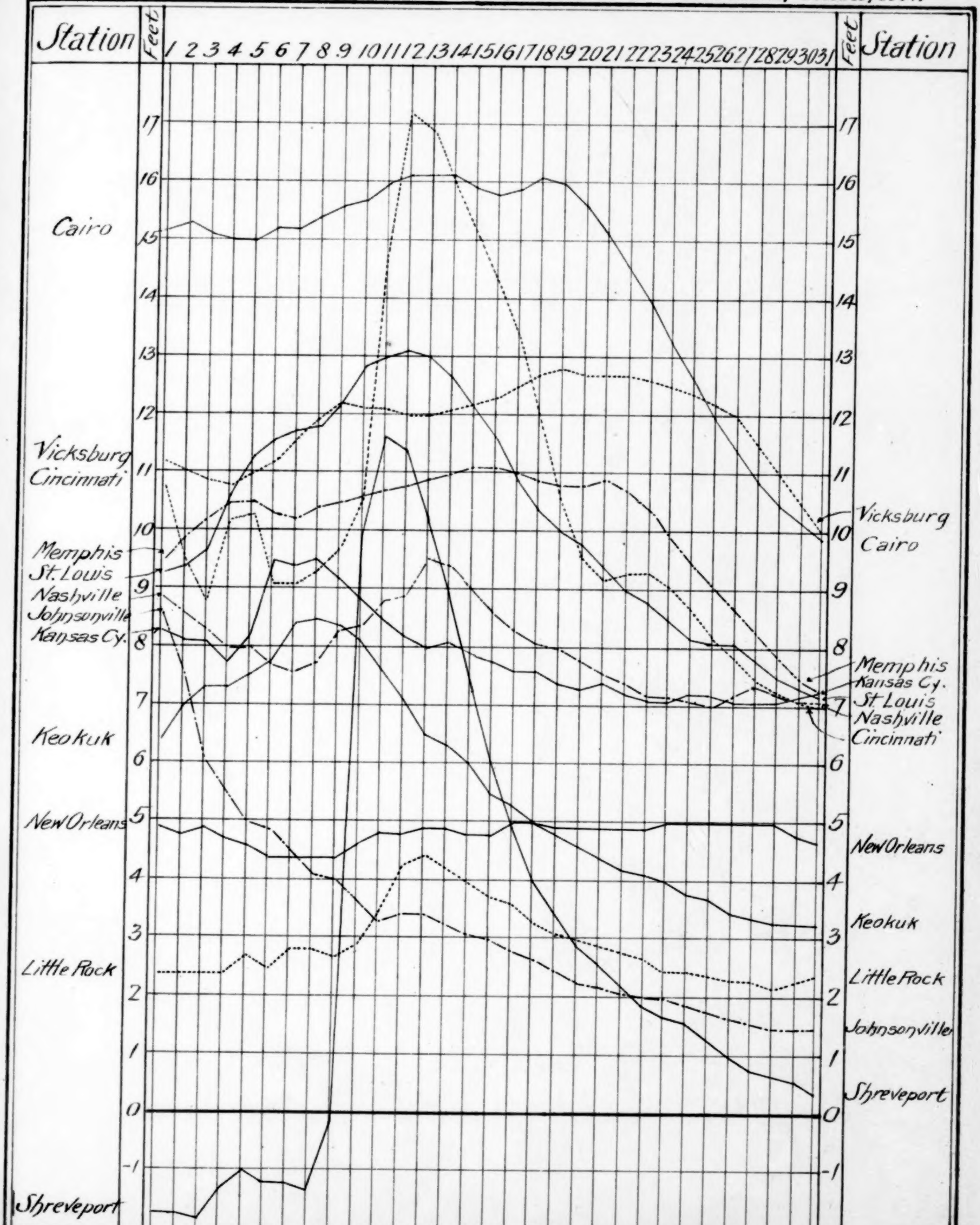

Chart II. Tracks of Centers of High Areas, October, 1907.

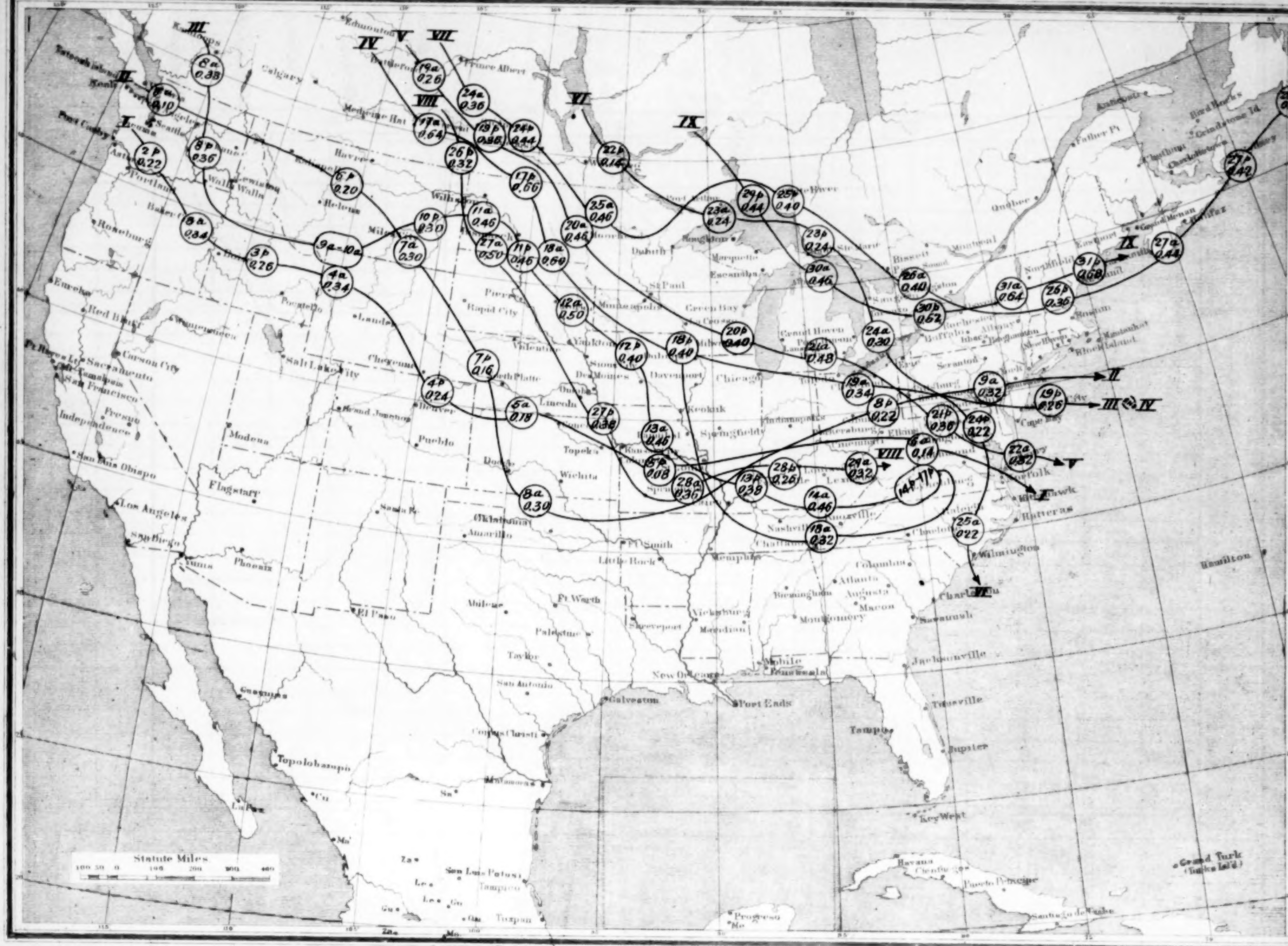

Chart III. Tracks of Centers of Low Areas, October, 1907.

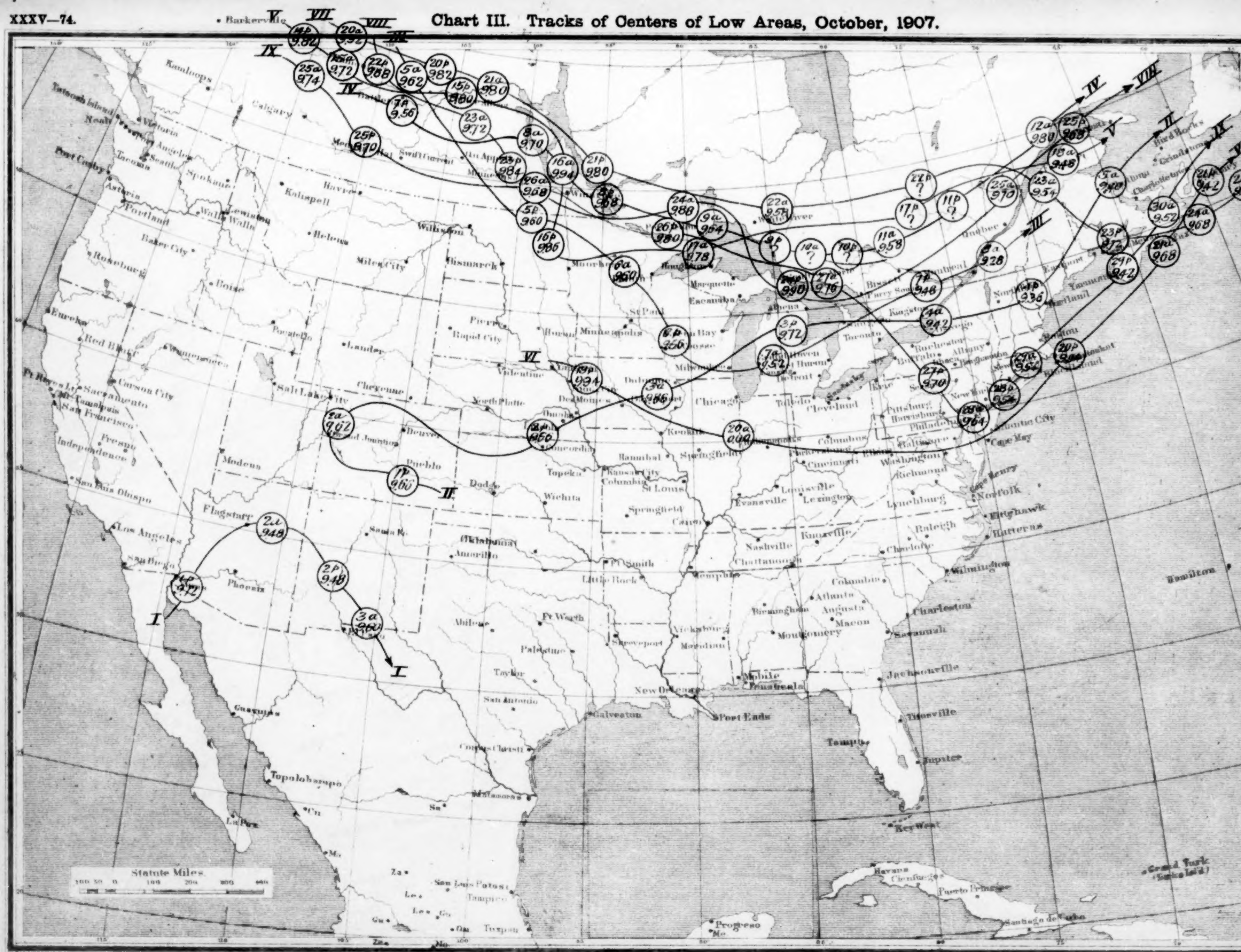

Chart IV. Total Precipitation, October, 1907.

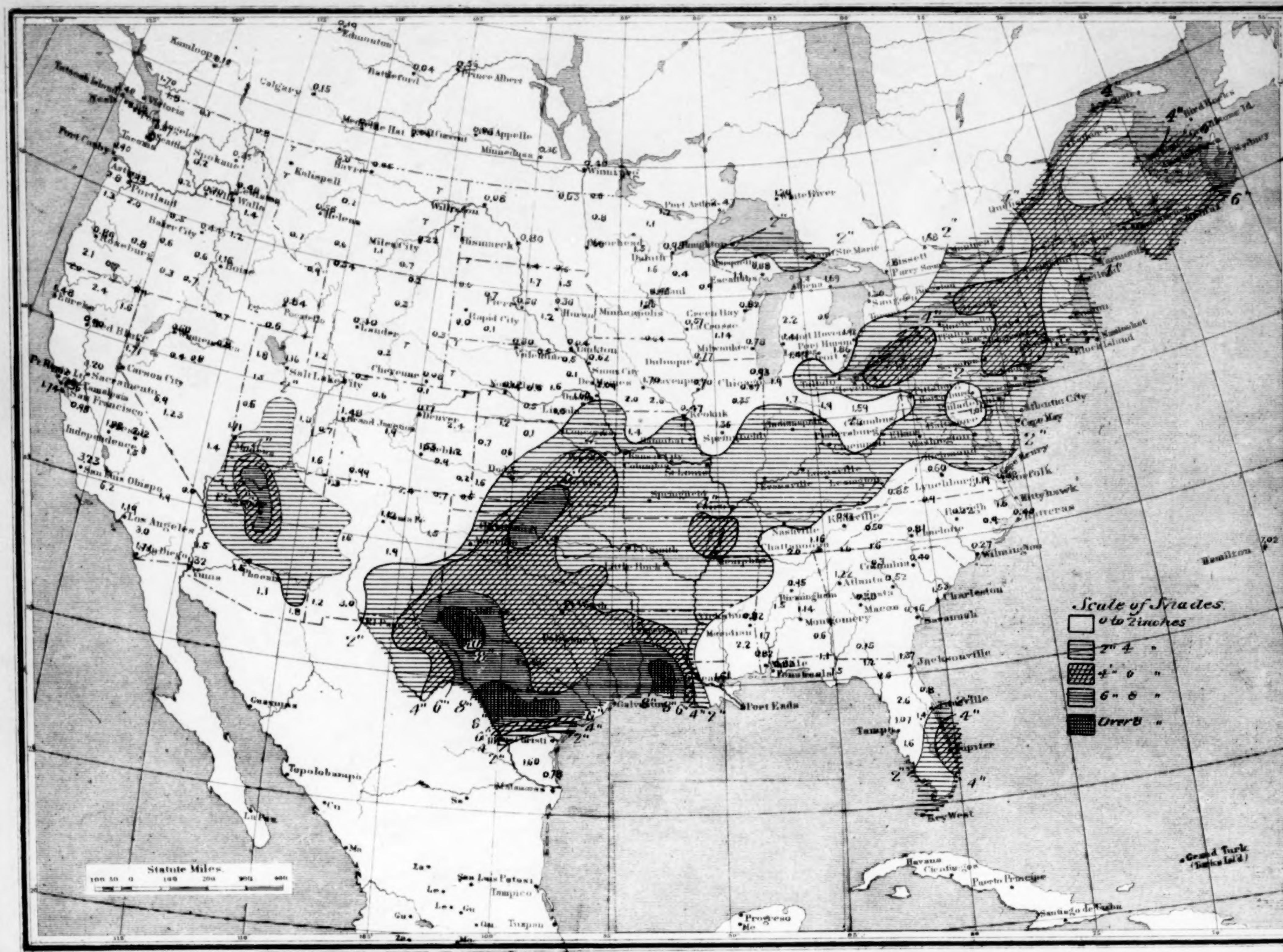

Chart V. Percentage of Clear Sky between Sunrise and Sunset, October, 1907.

Chart V. Percentage of Clear Sky between Sunrise and Sunset, October, 1907.

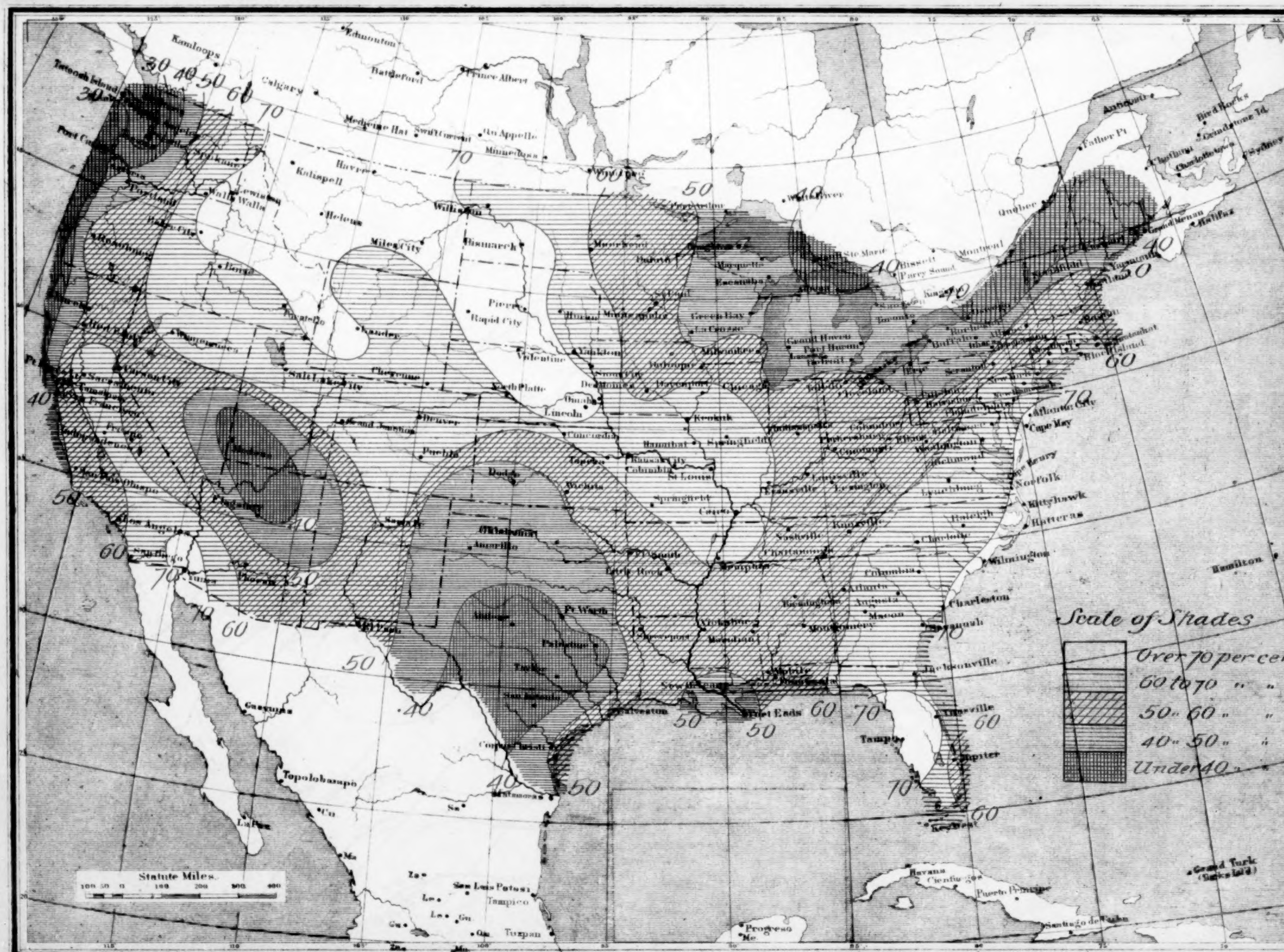

Chart VI. Isobars and Isotherms at Sea Level; Surface Wind Resultants, October, 1907.

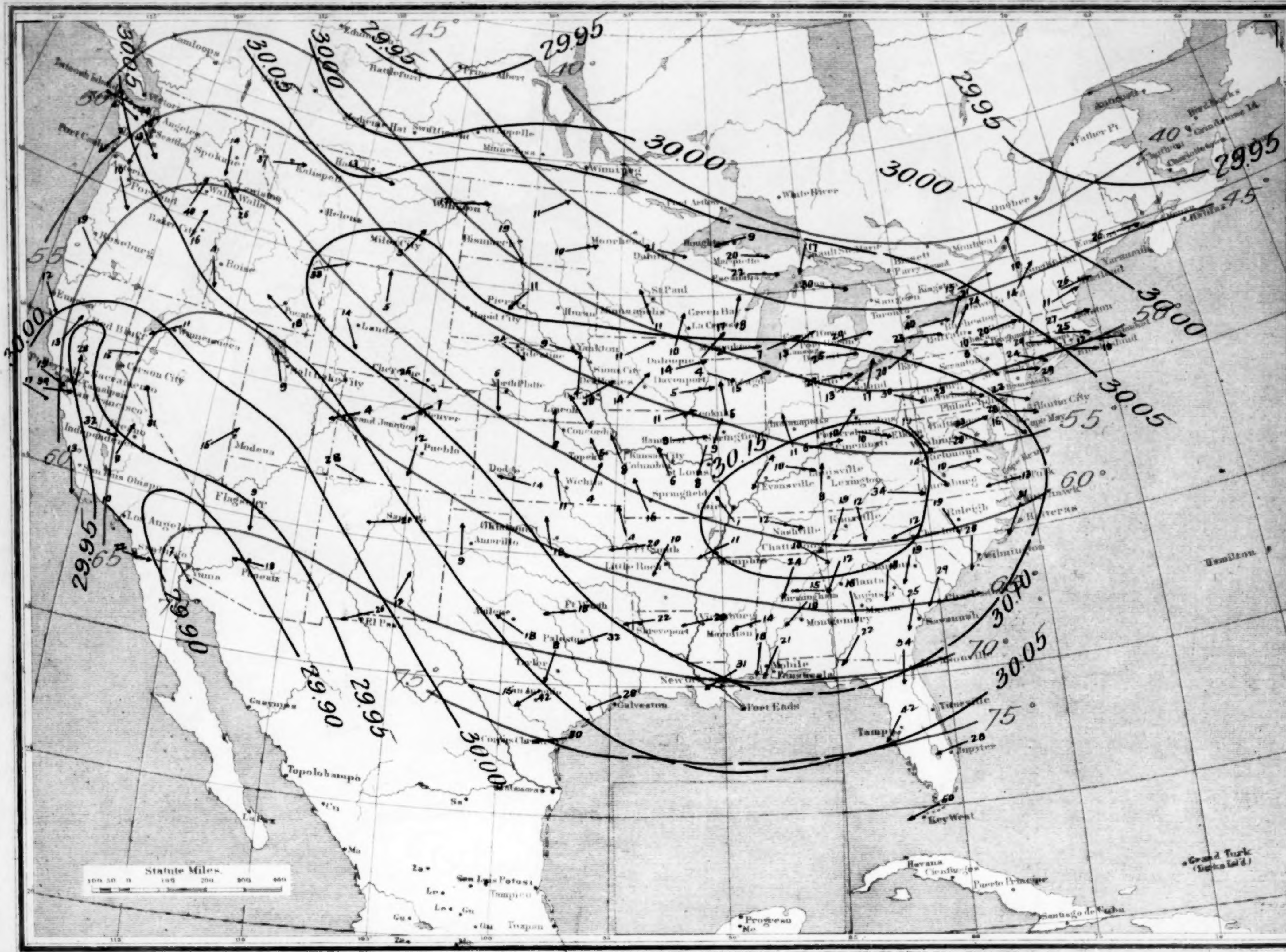

Chart VII. Total Snowfall for October, 1907.